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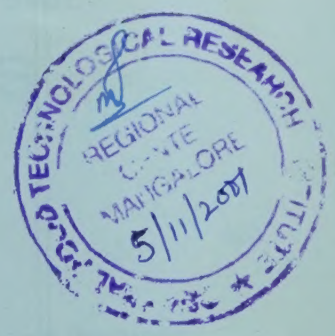

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REVIEW

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Vermicelli Noodles and Their Quality Assessment

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Vermicelli noodles are convenience products prepared mainly from wheat, as well as rice and from other sources. They have become major products of the cereal food industry and are popular on account of their sensory appeal, low cost, ease of preparation, storage stability and the increased consumer interest in ethnic foods. This review describes the origin and type of noodles, the variety of noodles as prepared from different source materials like wheat, and other cereals and millets, non-cereal grains, and roots and tubers. Parameters used for quality assessment have been discussed. Various analytical methods (sensory, physico-chemical, chemical and instrumental) being used for predicting the noodles quality have been described. The lacunae existing for the well defined terminology for sensory attributes and lack of its correlation with instrumental data have been pointed out. Packaging parameters for better shelf life of noodles have been discussed. In view of the increasing popularity of pasta products and growing market for convenience foods, the future scenario for vermicelli noodles is indicated.

Keywords : Noodles, Pasta products, Solid loss, Noodles texture, Noodles quality.

Cereals like rice, wheat, maize and millets are staple food grains for majority of population around the world. These are rich sources of carbohydrates, and supply calories and other nutrients to the consumers. Apart from value addition by processing to traditional products from these grains, development of newer products offers variety, convenience, quality, cost efficiency and scope for increasing the nutritional value. In the developed countries many convenience foods are prepared by extrusion process using forming extruder, as it offers a large number of desired characteristics to be incorporated in the product. Noodles are one of the many convenience foods prepared through this system and have been considered to symbolise long life and good luck in Asian culture. Macaroni products, alimentary pastas and pasta are the most important extruded products and are more or less synonymous. They depict a broad category of important products which include spaghetti, macaroni, vermicelli, liguini and noodles. These products can be described as hard, brittle pieces, formed into different shapes by extruding, cutting and drying tough dough made of semolina or farina mixed with water. It is the versatility of form, composition and ease of preparation at consumer end which has made these products so widely accepted the world over. The popularity of pasta can be attributed to its sensory appeal, versatility, low cost, ease of preparation, nutritional content and excellent storage stability as well as increased consumer interest in ethnic foods in the Western world (Cole 1991). The inherent blandness of the product makes them congenial with many kinds of adjuncts such as sauces, toppings, flavourings, etc, enabling vermicelli noodles to be used as the basis of different dishes with infinite variations. These dishes are consumed in place of potatoes, rice, bread and tortillas. Italians are world leaders in the consumption of pasta products with 25 kg per head per annum (Mariani-Costantini 1988), followed by USA at about 8.2 kg per head (Skinner 1991). Australians and Japanese consume about 3.5 kg and 1.1 kg per head, respectively (Miskelly 1993). Although consumption in India is reported to be very low, viz., 80 g/capita, their production has increased in the recent past, from 4.73 lakh tonnes during 1990 to 5.39 lakh tonnes in 1996. Projection for 2001 have been indicated at 6.46 lakh tonnes (Vetrimani et al. 1999). Pasta are projected to become more popular in many of the Asian countries with the increased availability of Western foods and higher disposable incomes (Miskelly 1993). All the pasta products are basically similar, differing mainly in shape and they comprise the following items (Irvine 1978) :

Macaroni – Hollow tubes of various lengths and diameters; Spaghetti – Solid rods, generally of small diameter; Noodles – Strips, either flat (rolled and cut) or oval round (extruded) and Shapes – Die-cut in various forms from sheets of dough.

The present review focusses on the noodles, specially the vermicelli noodles, with a view to take stock of the present knowledge on this fast becoming popular convenience product, and could serve as a guideline for future research in this area.

Origin and usage of noodles

The term, pasta and noodles are often used synonymously but differ in their origin, raw material and method of manufacture. Pasta usually refers to 'Italian style' extruded products such as spaghetti and macaroni. These are made from durum wheat semolina, which is very hard and vitreous. Noodles are usually made from soft wheat flour by a process of sheeting and cutting, or by a process of extrusion using a die with round holes of desired diameter to get strands followed by cutting.

Although Italy is generally regarded as the home of pasta products (Hummel Ch 1966) as their production was first recorded there about 800 years ago, there are views that Italians first learnt to make noodles from Germans, who had previously learnt the process during their Asian travels. Germans called this product *Nudeln,* which is still a popular type of pasta consumed in Germany (Donnelly 1991). During the fifteenth and sixteenth centuries commercial pasta production was developed in Naples in Italy as the climate was particularly favourable for drying of pasta products. By seventeenth century, the commercial pasta kneader and press were introduced (Mariani-Costantini 1988). From Italy, pasta spread rapidly to France, other European countries and America. The first commercial production in USA was in 1848 by Antoine Zerega,

* *Corresponding Author*

who established A. Zerega and Sons Inc. in Brooklyn, New York (Donnelly 1991). The spread of pasta worldwide has been relatively slow despite the continuous press for the semi-automatic production of pasta products in 1933 (Baroni 1988).

Asian style noodles originated in northern China, where wheaten foods or *biang* have been known since earliest times (Miskelly 1993). The art of making noodles was well developed during the Han dynasty, between 206 BC and 220 AD. During the Sung dynasty (960-1279 AD), cooked noodle dishes could be purchased in open air markets (Miskelly 1993). Noodles spread from China to Korea, Japan, The Philippines, Thailand, Malaysia, Indonesia, Singapore, Burma and Vietnam through Chinese traders, seafarers and migrants. In Japan, most types of noodles found today were certainly available by sixteenth century (Nagao 1981). Noodles were soon adopted and blended with local ingredients as part of the unique cuisines of these countries. In the Philippines the original Chinese noodles were transformed using native ingredients and Spanish cooking methods. Noodle shops or 'Panciterias' were operated by Chinese immigrants in the seventeenth century and such shops can still be found today (Alejandro 1983). The term 'Panciteria' is derived from two languages: Filipino *Pancit* for noodle, which in turn evolved from the Chinese *fen xi,* meaning 'bean thread', and the Spanish suffix 'eria' meaning store (Barum 1985). In China, rice noodles are called *mu-fen* made from rice only. In Japan, it is called as *harusame* made from rice, mung been starches or a mixture of these (Hsieh and Luh 1991).

Flour-based noodles were common and were made from rice flour, buck wheat flour, wheat flour and from bean, potato, mung bean and corn starch. The major manufacturing methods depend on the presence or absence of gluten. Small amounts of nutrients may be added but these do not affect the organoleptic qualities or processing properties of the material. Water is added as a processing aid in the extrusion step and is removed by drying, except when it is sold as fresh product. Wheat flour noodles are usually produced by sheeting and rolling, while other types are typically processed by extrusion or batter cooking methods (Miskelly 1993).

Rice noodles are widely consumed in China, Japan and Southeast Asian countries since ancient times. The raw material for rice noodle is non-glutinous rice which is elastic and enables formation of a dough that is easy for extrusion (Hsieh and Luh 1991). Mung bean noodles are also widely consumed in the orient. These noodles are usually thin, and are transparent or translucent, both before and after cooking. They are moderately chewy after cooking and have a bland taste which is due to the unique properties of mung bean starch.

European type noodles

In Europe, as mentioned earlier, the pasta products are made preferably from durum wheat *(Triticum durum)* and are superior in colour and quality to those from bread wheat *(Triticum aestivum)*. For pasta preparation, semolina and about 30 % water are mixed batch-wise or continuously, preferably under vacuum. The dough is then extruded through a brass die with teflon inserts, cut to the right length and dried to about 11-13 % moisture at regulated temperature and humidity which is critical. If the drying is slow microbial spoilage sets in and if the drying is fast, it results in cracking or checking. High temperature drying (70°-90°C) has also been used, which reduces the drying time and improves product quality (Pavan 1980). Eggs are added sometimes to improve the sensory attributes, vegetables extracts such as tomato and spinach are added to incorporate flavour, fibre and protein. Filled products like *ravioli* and *tortellini* are also available. Pasta can be canned to produce varieties such as spaghetti with tomato sauce. Microwaveable 'thin walled' pasta and 'instant pasta' have been developed which are precooked before drying. Use of modified atmosphere and vacuum packaging has greatly increased the availability of fresh and semi-fresh pasta with better shelf life (Miskelly 1993). The traditional Italian dish called *Lasagne* is in the form of wide thick ribbons, often with a wavy edge. It is available in the market as dried or precooked *Lasagne* or *Cannelloni.* It is prepared by extruding the dough as sheet, rolled to uniform thickness, cut to size, cooked in boiling water, rinsed, followed by drying, stacking and packing. The pasta sheet is moved on a sheet traction system giving it a characteristic corrugated shape (Matz 1991).

Asian type noodles

Asian type noodles are usually made from wheat flour, rice flour or starch from bean, potato or corn. *Saimin* and *Chow funn* are the common wheat based Asian pasta products (Douglass and Matthews 1982). Cereals like rice, and isolated starches do not contain gluten, like in wheat, and therefore require gelatinisation during processing as a binder (Juliano and Sakurai 1985). The manufacturing methods thus depend on the presence or absence of gluten. Wheat flour noodles are produced by sheeting and rolling, whereas other types are typically processed by extrusion or batter cooking.

Starch-based noodles are made generally by mixing starch with boiling water and kneading by hand to proper smoothness and then rolled out into thin square sheets. These are used to make the semi-transparent or opaque *dim sum* wrappers for Chinese shrimps and also for meat dumplings such as *her gow* and *fun gor.* The same dough is also used at home to make the nail-shaped 'silver pin noodles' which are about 5 cm long (Passmore 1991). Noodles made from mung bean starch are known as 'bean thread', 'starch' or 'cellophane' vermicelli. In China, the noodles made from mung bean or starch other than rice is called *fung-shu* (or *tong-fun*). Mung bean is generally grown in Asia and to a small extent in Australia. The mung bean starch is isolated by a wet milling process before being cooked or treated with sulfur dioxide for 30 min. The treated starch is mixed with gelatinised starch and water and the dough is passed through a sieve under pressure, extruding the noodles into boiling water, where they get cooked. These are then drained and frozen for 24 h, defrosted and dried in sun or air before packing (Prabhavat 1988). These noodles cook quickly and loose less solids on prolonged cooking and have a distinctive chewy texture. These textural characteristics are due to the unique properties of starch which is cross-linked and has restricted swelling properties (Lii et al. 1988).

Mung bean starch can be replaced by modified potato and

sweet potato starches and is said to give satisfactory noodles (Chui ad Chua 1989). Ramen is a very quick cooking form of pasta prepared by immersing in hot water. These noodles are pre-cooked by both steaming and frying and then dried. They are usually made from wheat flour rather than durum semolina and seldom contain eggs (Matz 1991).

Rice noodles are prepared by two main methods, namely extrusion to produce vermicelli types, and sheeting of a batter to produce sheets and flat noodles. Filipino *bihon* are vermicelli noodles made from high amylose rice, which is wet milled and filtered and made into balls. The balls are precooked in boiling water for 20 min, or steamed, to enable surface gelatinisation. The dough balls are kneaded for uniform distribution of gelatinised rice and extruded through a die. The extruded noodles are boiled and cooled, or steamed for 10-15 min and sun-dried (Juliano and Sakurai 1985; Juliano and Hicks 1996). These noodles are softened in hot water prior to use. These cooked noodles form the base of special dishes as they absorb the flavours of other ingredients used in cooking. Rice vermicelli noodles should be fine (about 1 mm diameter), white and translucent and should maintain their smooth surface after rehydration (Juliano and Sakurai 1985). Resmini and Pagani (1983) reported that rice pasta made with lower proportion pregelatinised flour produced better quality noodles than that with 100 % gelatinized or raw rice flour. In Thailand, Myanmar (Burma), Vietnam, Singapore, Indonesia, Malaysia and China, sheeted or flat fresh noodles are popular. They are made by a batter process using wet milled rice flour and water. The batter is coated on to a rotating heated drum and the formed sheet (about 1 mm thick) is removed and conveyed to a steaming tunnel for gelatinisation. The noodles can be sold as sheets or cut in to 1 cm wide strips to make fresh rice ribbon noodles such as thai *gwayteo or* Malaysian *kway teow.* In many Asian open air markets, rice rolls or *cheong fun* can be purchased. The wrappers are made freshly from rice dough batter, which is steamed in layers in cloth lined baskets or directly on a hot plate under a wet cloth. Rice noodles can also be dried before sale. Flat dried rice stick noodles known as *banh pho* are used in the popular Vietnamese noodle soup known as *pho* (Miskelly 1993). In the United States, some pasta producers have made a 100 % rice pasta, from a dough made of raw and pre-gelatinized rice flours. This dough is then processed in a pasta extruder to produce the final shape. The extruded products usually have a sticky, texture (Kohlwey et al. 1995).

Varieties of noodles

Wheat-based noodles

Noodles made from wheat flour are an important part of the diet in many Asian countries accounting for up to 40 % of local wheat flour consumption. They can be sub-divided on the basis of colour as white salted or yellow alkaline. The yellow colour is due to the addition of alkaline salts such as sodium or potassium carbonate (also known as *Kansui* or lye water). The water soluble compounds responsible for this yellowness at high pH have been identified as apigenin glycosides (Mares 1992). Alkaline noodles have a high pH (9-11) and a characteristic flavour and chewy texture. Various types of yellow noodles (with egg sometimes added to the dough) are common in Malaysia, Singapore, Indonesia, Thailand, Southern China, Taiwan, Hongkong and Japan. White salted noodles are consumed mainly in Japan, China and Korea (Miskelly and Gore 1991).

The flour based noodles are made by hand either as Chinese *la mian* or hand swung noodles which are skillfully pulled and stretched in to a long rope by repeatedly folding in half between each drawing stage (Huang 1996). The other common method at home is to roll out a dough sheet thinly (not unlike pastry), fold it over and cut it into strings with a knife. About 80% of noodles are still made by hand in China but in most other countries, the process is fully or partially mechanised. In Japan, hand-made noodles such as *Tenobe Somen* and *Teuchi Udon* are highly valued over machine made noodles because of superior eating texture. This is thought to be due to differences in the way the gluten structure is developed during processing (Nagao 1981). Flour-based Asian noodles are produced by relatively simple process. Flour, salt (1-3%) or alkaline salt (1%) and water (usually 32-35% and may vary) are mixed together to evenly distribute the ingredients and hydrate the flour into dough balls of varying sizes. Other ingredients may be egg, colouring agents, preservatives and gums). A flow chart for the production of Asian wheat flour noodles is given in Fig 1.

The dough balls are converted into a dough sheet by passing between steel rollers, 3 - 6 mm apart. However, in less mechanised small factories, the dough is first compressed by dexterous use of a long bamboo pole or a stamping machine prior to the first sheeting stage. The dough sheet is often rested

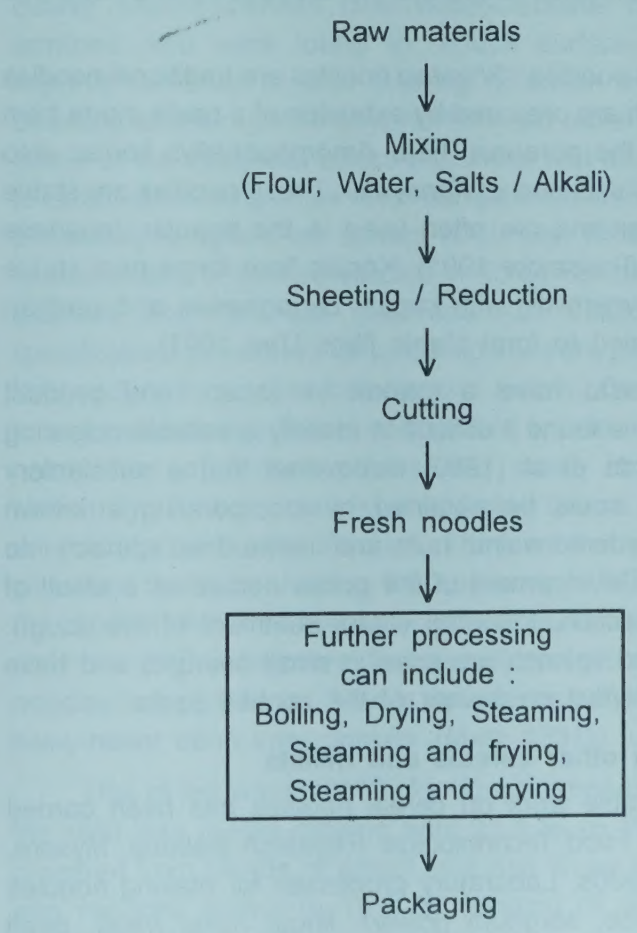

Fig. 1. Flow chart for the production of Asian wheat flour noodles (Miskelly 1993)

to relax the gluten structure before one or two combined dough sheets are passed through a further sequence of 3 - 7 rollers. These sheeting stages serve to develop the gluten - starch network (Moss et al. 1987) and reduce the dough sheet to the desired thickness of 1 - 2.5 mm. Sheets are cut into strands using slotted cutting rolls to produce noodles of 0.6 - 6.0 mm wide, which are then cut to lengths of 180 - 260 mm. Fresh noodles which contain about 35% moisture are sold without further processing. Noodles are dried to about 10% moisture in special controlled temperature and humidity drying chambers in a process somewhat similar to that used for pasta. Sun-drying of noodles is still done if the climate is conducive. *Hokkien* noodles from Malaysia and Indonesia, and some Japanese *Udon* are partly boiled before sale. Both fresh and boiled noodles have a relatively short shelf life in tropical areas where manufacture, storage and distribution conditions are not ideal. The shelf life can be extended by hygienic manufacturing practices and refrigeration or freezing of products. The use of retort pouch packaging under aseptic condition has increased the shelf-life of these products to several months in Japan. These noodles are often sold packed in a heat proof cup or bowl with various flavourings and toppings and are quite popular.

Noodles from tubers and roots

Taro noodles : Moy et al (1980) have reported development of an extruded product in the form of noodles from taro corms. Taro (*Colocasia esculenta* L. Schoot) is a tropical root crop, is rich in starch and has high energy value. Taro noodles are prepared from taro corms by washing, peeling, slicing, air drying and grinding and extruding in the form of rice, noodle or macaroni. Mung bean flour or soy protein are added to the dough before extrusion to improve the extrudability and nutritional qualities.

Shirataki noodles : Shirataki noodles are traditional noodles of Japan which are prepared by extrusion of a paste made from the tubers of the perennial herb *Amorphophallus konjac* also known as devil's tongue or *Konnyaku.* These noodles are stable in boiling water and are often used in the popular Japanese dish *Sukiyaki* (Passmore 1991). Konjac flour forms heat stable gel which is synergistic with kappa- carrageenan and xanthan gum and is dried to form stable films (Tye 1991).

Black pasta have a market in Japan, and product developers have found it difficult to identify a suitable colouring agent. Leonardo et al (1989) discovered that a satisfactory black product could be obtained by incorporating a known quantity of powdered walnut hulls and freeze dried spinach into pasta dough. Development of the colour occurs as a result of an enzyme reaction, following steam-treatment of the dough. Walnut hull and spinach are used in small amounts and have no significant effect on flavour of the cooked pasta.

Noodles from other cereals and millets

Considerable work on cereal noodles has been carried out at Central Food Technological Research Institute, Mysore, India during 1990s. Laboratory processes for making noodles from rice, maize, sorghum *(jowar),* finger millet *(ragi),* pearl millet *(bajra),* foxtail millet *(navane)* and little millet *(samai)* have been developed and patented (Sowbhagya and Ali 1994, 1996, 1998, 1999, 2000). The noodles are quick cooking and have good appearance. The cooked noodles are stable and can withstand further handling for preparation of many end dishes. The salient steps for making noodles are shown in Fig 2.

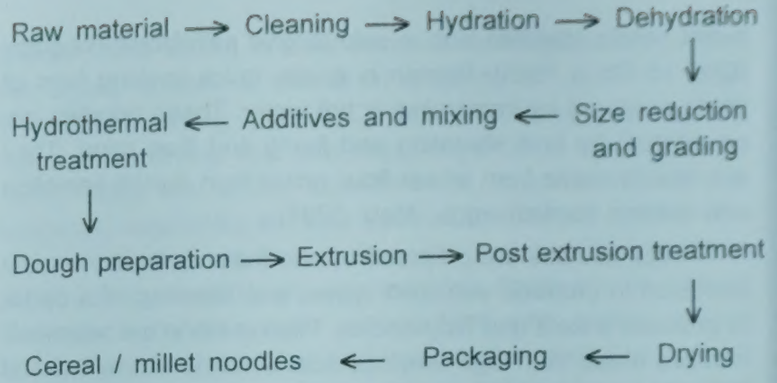
Raw material → Cleaning → Hydration → Dehydration
Size reduction and grading
Additives and mixing ← Hydrothermal treatment
Dough preparation → Extrusion → Post extrusion treatment
Drying
Packaging ← Cereal / millet noodles

Fig. 2. Flow diagram for production of cereal / millet noodles

Noodles have also been produced from triticale, a polyploid hybrid cereal produced by cross-breeding wheat and rye. However the triticale noodles exhibit more solid loss than wheat noodles (Lorenz et al. 1972).

Barley noodles are prepared by combining of 75% barley flour (from waxy, hull-less barley) 25% wheat semolina flour, egg and water. The barley and semolina flours are blended at low speed for 2 min, the egg and water mixed together previously, are gradually added and the dough is mixed to optimal consistency. The dough is sheeted and cut in a noodle machine, air dried at room temperature for 20 h and stored (Berglund et al. 1992). Due to incorporation of waxy hull-less barley flour with wheat flour, both total fibre and soluble fibre content are increased to produce high-fibre food which may appeal to consumers interested in this class of foods.

Noodles from buck wheat

Buck wheat, a triangular seed with a tough outer hull (Fagopyrum spp.) is not a cereal but rather a member of the polygonaceae family. In Japan *Soba* noodles are made from buck wheat and account for 7% of total noodle production (Crosbie 1990). Up to 60%, wheat flour is mixed with buck wheat flour and the noodles are made by hand or machine. *Soba* is usually greenish brown in colour. Deep green colour *(cha soba)* is achieved by the addition of Japanese green tea powder to the dough. Buck wheat noodles have a firm and elastic eating texture, attributed to the high paste viscosity of the buckwheat endosperm (Shiratori and Nagata 1986). The flour has a characteristic 'pea' flavour and aroma which disappears rapidly with time after dehusking and milling (Miskelly 1993).

Instant noodles

Instant rice noodles are a speciality developed in Japan, Taiwan and other Far Eastern countries. The processing method is almost identical to that of the conventional rice noodles, except that instant noodles can be easily reconstituted in hot water in a few minutes. In this process, the steamed noodles are dried at a high temperature to prevent the gelatinized starch from undergoing retrogradation. Normally, hot air at 80°C is used, but some plants are frying instead of hot-air drying.

Usually non-glutinous rice (preferably 92% milled rice of non-glutinous 'Taichung Native 1') is soaked in water for 2-4 h, ground into a rice paste which is then pressed to force out the excess water. This rice cake is steamed for 80 min (80% gelatinisation is the optimum condition), kneaded and then extruded. The extrudate is steamed for 30 min, dipped into a seasoning solution, cut, put on to racks for hot air drying on fried in oil which has a temperature above 80°C. The final product (instant rice noodle) is then cooled and packed. Another kind of snack *bitaibah* is made into a wet type of noodle with wider diameter and shorter length (Hsieh and Luh 1991).

The traditional noodles have been modernised and globalised in the form of instant noodles. Both rice and wheat flour type instant noodles are steamed and dried or steamed and fried after the cutting stage. The modern instant noodles are steamed and fried usually in palm oil, have a fat content of about 20% and a shelf life of 4 - 6 months (Gore et al. 1988). Instant noodles are fast cooking, needing only 2 - 3 min boiling or rehydration in boiling water. Modern instant noodles *(Ramen)* were first marketed by Nissin Foods, the largest noodle manufacturer in Japan. Instant noodles were introduced to the USA in the early 1970's and they have found a huge market. They are now manufactured in different countries like USA, Australia, Papua New Guinea, Korea, The Philippines, Thailand, Vietnam and many European countries. Recently, it is extended to Netherlands and Saudi Arabia. Australians consume an estimated 77 million packets of instant noodles per year (Anon 1991) with a grocery value of $38 million and annual growth rate of 14% (Anon 1992). In Korea *Ramyon* an instant noodle introduced in 1963 has replaced traditional noodles to the extent of 90% of total noodle production (Kim 1996). In Korea, the consumption of instant noodles is 10 kg per head in 1987 (Kim and Lee 1989) and instant noodles are considered as a meal rather than a snack and the taste and flavour of the soup is considered even more important than the texture of the noodles.

Quality of noodles

Quality attributes, effect of compositions and processing

Appearance, texture and flavour are the major quality attributes which influence the sensory acceptability of a food including pasta products such as vermicelli noodles. Predominant characteristics that define the quality of the pasta are therefore related to appearance and textural factors such as translucency, colour (in case of wheat pasta), uniformity of appearance, mechanical strength and integrity, absence of sticky surface and 'al dente' (soft), and eating properties as characterized by high degrees of firmness and elasticity (Hoseney 1986). During cooking, the product should maintain its form without disintegration, increase substantially in volume, exude minimal material into cooking water and exhibit tolerance to over-cooking (Holliger 1963; Cole 1991). Fresh pasta is susceptible to several factors that lead to decline in product quality like fungal contamination, surface dehydration and enzymatic browning.

Pasta quality is a geographically variable factor in that, what is acceptable in one country is not necessarily acceptable in another. The objective and subjective evaluation of pasta in the laboratories around the world has evolved with the perceived needs of the indigenous consumer. For making wheat-based noodles, Australian wheat is used in Japan, Korea, China, Malaysia, Singapore, Thailand and Indonesia as the wheat is supposed to be clean, low in moisture content, has white bran coat and gives high flour yield. The extent of darkening of fresh noodles with time is less with the white wheats as the residual brans have less colour than American red bran wheats (Crosbie et al. 1990). This darkening has been attributed to the action of polyphenol oxidases by a mechanism similar to the enzymic browning of many fruits after peeling. The firmness of bite is dependent on protein content and protein quality (Matsuo 1988; Miskelly and Moss 1985). These factors, with colour attributes, are assessed in most durum wheat pasta products. Noodles with firmer texture are preferred in Japan, Thailand and China, and are made using a high protein flour. Consumers prefer noodles which are bright and clean in appearance but the degree of yellowness varies according to the region.

In Italy, for the evaluation of cooked pasta, characteristics like stickiness (surface disintegration of the cooked product estimated by visual inspection with or without the aid of a standard reference pasta), firmness (resistance of the cooked pasta when chewed or flattened between fingers or sheared between the teeth) and bulkiness (degree of adhesion of pasta strands after cooking, evaluated visually and manually) are widely applied and accepted (Fabriani and Lintas 1988). Wheat sprout damage adversely affects semolina speck count and spaghetti shelf stability (Donnelly 1991). The wheat lipids have been found to exert marked influence on spaghetti cooking quality. Monoglycerides form water-insoluble complexes with amylose, and were found to reduce surface stickiness but improve tolerance to over cooking (Eliasson and Krog 1985). Blending wheat regrinds beyond 15% can adversely reduce the colour of the spaghetti, cooked firmness and also the tolerance to extended cooking times when compared with a 100% semolina processed spaghetti as control (Donnelly 1980). The textural characteristics of cooked noodles in Korea include cohesiveness, elasticity and hardness (Lee and Kim 1983). In India the specifications prescribed for wheat noodles are generally followed for noodles from other cereals and millets. Consumer prefers to buy pasta having yellow, translucent appearance (for wheat), nearly free of broken pieces and small, loose fragments. Uniformity of piece size and shape also seems to be regarded as indicator of quality. Texture of the cooked pasta is a very important factor in shaping the consumer's final evaluation of the product. Any off-flavours or odours such as musty, sour or stale are highly negative factors, whereas blandness of the noodles is a plus factor. This is the reason why flavoured pasta have never been very popular (Matz 1991).

Use of hot water (75°C) for dough preparation decreased the solid loss during cooking from 22.1 to 16.1% for vermicelli prepared from blends of wheat flour and finger millet flour. This was reduced further to 13% by toasting of dry vermicelli at 120°C for 3 min (Sudha et al. 1998). In case of composite dough containing finger millet (FM), and milled wheat fractions (Whole wheat flour (WWF), wheat semolina, wheat flour) the

water absorption for making dough increased with increase in FM content. Blending FM flour with WWF up to 50% reduced the cooking loss to 8.6%. The vermicelli tended to be quite tender and discrete. Also the cooked weight increased by more than 3.8 times.

Analytical methods

The analytical methods for quality evaluation of noodles could be broadly classified into 3 categories viz. sensory, physicochemical and instrumental. Instrumental methods of evaluation of textual properties were developed primarily for experimental work with long, solid rods such as spaghetti and are not universally applicable to the wide array of sizes and shapes including oriental noodles. Microscopic examination of ultra-structural components, application of fundamental testing methods to investigate the mechanical behaviour of food materials under deformation have been suggested as potential predictors for selected sensory attributes of solid food materials (Segars and Kapsalis 1987). Cole (1991) in his review has expressed the opinion that for evaluation of pasta, more emphasis has been laid hitherto on physical and chemical measurements than on sensory appraisal. Failure to use trained panelists and well-defined terminology for sensory attributes and lack of its correlation with instrumental data are the major reasons, for slow progress in this field. Careful sensory studies incorporating appropriate protocols, and adequate replication should be undertaken to provide support for replacement of time-consuming sensory procedures with rapid physicochemical or instrumental tests for routine analysis (Cole 1991).

Sensory tests

The important sensory parameters are appearance, colour, flavour and texture. Usually appearance and colour are more or less synonymous terms one complementing the other. However, there are no standard procedures existing for the determination of these properties (Donnelly 1991).

(i) Appearance : Apart from colour, the sample is observed for some serious flaws like 'check', 'split' and 'deformation'. Flaws like large bubbles, small bubbles, white specks, dark specks, rings, streaks and roughness are scored against a standard sample prepared (Matz 1991).

(ii) Flavour : Flavour of cooked pasta products is reported to be a minor quality attribute from a consumer stand point (Larmond and Voisey 1973) and seems to play a lesser role than texture or appearance in the overall quality of pasta. The flavour in noodles has been identified as similar to that of starch, raw or cooked cereals and whole cereals (Voisey and Larmond 1973). The off-notes include mustiness, moldiness, sourness, bitterness, vegetable and cardboard flavours.

(iii) Texture : Scoring for textural characteristics like stickiness, bulkiness and firmness with 3-point scale and a complex scoring system by a small panel of 3 experts was employed by Italian investigators (D'Egidio et al. 1982). However, Pangborn (1984) has opined that scales with a limited number of categories might not serve as sufficiently sensitive instruments for discernment of differences among food products within a specific class. Japanese workers have developed a complicated sensory methodology for subjective assessment of selected quality characteristics like appearance, texture and taste of Japanese noodles (Toyokawa et al. 1989). Similar to Italian evaluation scheme for spaghetti, the Japanese system utilizes a small number of panelists (three to five) who perform a series of Hedonic judgements with a weighted scoring system, based on 100 points and divided into three primary scale ranges (good, standard, poor). In the Japanese scheme, texture of noodles is subdivided into three major characteristics :

(i) Hardness or firmness (worth a maximum of 10 points of the total score); (ii) Smoothness or mouth feel during mastication (worth a maximum of 10 points) and (iii) Viscoelasticity or 'viscosity and elasticity' (worth a maximum of 20 points).

Viscoelasticity is a technical term from the field of rheology which would have little sensory meaning to even the most highly trained expert panel. Even though cumulative scales utilized by many workers in the field of sensory analysis corroborate use of small panels of highly trained and experienced experts, Larmond (1987) has stated that panel size should approach 10 individuals to avoid excessive dependence on responses obtained from any single participant. Other European workers have evaluated sensory quality of cooked pasta on the basis of visual, tactile or oral assessments of stickness, surface swelling, bite firmness / elasticity and colour (Larmond and Voisey 1973). ISO (1985) has proposed standard definitions of two sensory attributes of cooked spaghetti (1) surface condition (2) firmness. The ISO system has not been adopted extensively within the pasta industry. In USA and Canada, the sensory testing techniques for pasta and noodle products is projected to have limited scope.

Physico-chemical tests

These tests include determination of solid loss during cooking, water uptake or swelling ratio.

Solid loss is determined by cooking noodles strands of specific length in boiling water for 10 min during which the level of the water is maintained throughout the cooking period (BIS: 1485 - 1976). After this, the cooked material is strained into a beaker and the whole filtrate is transferred quantitatively to a tared Petri dish and evaporated over a water bath, followed by drying in an oven at 105°C ± 1 for 3 h and weighing the solids. A solid loss of less than 6% is considered very good and about 8% as average (Matz 1991). The cooked noodles are also weighed separately to obtain water uptake (g/g) or swelling ratio.

The Borazzio cooking test has considerable acceptance in Europe and the test equipment was made by Buhler Brothers (Matz 1991). Two hundred and fifty grams of dry product is cooked in 1% salt solution in each of two cooking vessels which are heated in a constant temperature oil bath maintained at 218°F. The products cook at a temperature of 208°F, so that disintegration of the product is held to a minimum. The cooking time in one vessel is 18 min and in the other 28 min. After this, the samples are drained for 5 min and weighed. The difference between the cooked and the dry sample is recorded as the water absorption during cooking. Volumes of the dry sample and the cooked sample are measured by water - displacement

method and the increase in volume is recorded. The water in which the samples have been cooked is placed in a graduated glass tube and the suspension of starch and other materials allowed to settle for 0.5 h. The height of the milky portion which settled out at the bottom is measured.

Another complicated test (Radley cooking test) has also been suggested (Matz 1991) which appears to be applicable more to research work than to quality control. In this test, about 3 g material are placed in a wire basket having a lid. The sample and container are weighed in cold water at 68°F and are then plunged rapidly into boiling water. The product is removed from the boiling water at a determined time and reweighed in cold water. It is then slung to remove the moisture and the outside surface of the basket is wiped dry. The basket is then weighed in air. The product is returned to the boiling water and the weighings repeated. The sequence of operations is repeated until the product has completely disintegrated and the empty basket is weighed in water. The curve plotted from the weight values determined in air indicate the rate of absorption of water. The curve obtained by plotting the values obtained by weighing in water shows the rate at which the product is disintegrating since the water absorbed by the macaroni does not contribute to the observed weight when the product is submerged (Matz 1991). A similar test as above has also been reported by Irvine (1978). Cooking pasta in distilled or deionized water has been reported to minimize differences among pasta samples whereas preparation in tap water, mineral water, well water or specially prepared solutions accentuate product differences (D'Egidio et al. 1981).

Bhattacharya et al (1999) have studied various physicochemical properties of rice in relation to quality of noodles prepared from 11 genotypes. The pasting parameters from the viscogram obtained on Rapid Viscoanalyser (RVA) instrument, and the parameters of gels formed in the RVA canister, correlated well with the actual noodle texture and are suggested to be used for predicting rice noodle quality during early screening of genotypes in breeding programs.

Additional physico-chemical techniques for prediction of pasta quality, including the determination of the extent of disintegration of pasta during cooking, and measurement of water absorption of the cooked product by gravimetric and volumetric methods have been outlined (Dick et al. 1986).

Chemical tests : Several chemical methods for assessment of gluten quality have been devised despite the tenuous association between most chemical measurements of gluten quality and end-product quality. Primary tests include: (1) Berliner test (Matsuo 1975) (2) Sodium dodecyl sulphate - sedimentation test (Dexter et al. 1980) (3) Specific absorbance test (Matsuo et al. (1982). Theoretically, total organic matter (TOM), rinsed from the pasta surface, reflects the quantity of starch and other biochemical components that are released from the protein matrix of cooked pasta and subsequently adhere to the product surface. Hence TOM values of rehydrated pasta should correlate closely with visual, tactile, or oral perceptions of surface properties like stickiness or adhesiveness (Cole 1991).

Sgrulletta and Destefanis (1989) have measured acetic acid - insoluble protein residue (IR) of 22 samples of semolina. Preliminary results suggested that IR correlated highly with sensory assessments of the textural characteristics of the finished pasta products ($r = 0.796$, $p<0.001$).

Instrumental tests

(i) Colour : The colour of cooked pasta (wheat and maize) can be evaluated by using instruments like reflectance meter, colorimeters such as Hunter D25 or the pacific scientific XL-800. Extraction of carotenoid pigments with water saturated n-butanol is carried out followed by measurement of absorbance at a specific wavelength, usually 440 nm (Irvine 1955). Lutein is the predominant pigment imparting a yellow or amber hue to wheat pasta. The measurement of absorbance of extracted pigments is done at a wavelength of 449 nm, where lutein exhibits its maximum absorbance and the results are expressed on a lutein basis (Matsuo 1988).

(ii) Texture : Texture can be measured by the Instron Universal Testing machine equipped with a special plastic cutting edge (Matz 1991).

Rheological properties of pasta and noodle dough have been measured instrumentally and have been utilized widely in predicting textural characteristics of finished pasta products. A review by Cubadda (1988) explains the benefits and limitations of existing instrumentation including farinographs, mixographs, alveographs, extensographs, aleurographs and viscoelastographs for measurements of the rheological characteristics of pasta dough. Holliger (1963) describes an apparatus, which measures the mechanical properties like stretching and bending of both uncooked and cooked spaghetti. The tensile testing methods have been used to measure mechanical properties of cooked noodles, but have limited use because of the inappropriateness of tensile tests for small sized or miniature goods, difficulty in handling the sample to the test cell and the tendency of the specimen to rupture near the point of contact (fixtures) (Voisey and Larmond 1973). Using Viscoelastograph, Alary et al (1978) found that compressibility and recovery values were closely correlated for cooked discs of semolina dough and strands of cooked spaghetti. Sowbhagya and Ali (1994) have also used this instrument for measuring the textural properties of vermicelli noodles. Firmness and elastic recovery of the noodle strands are measured. For this, three strands of cooked noodles are compressed between two parallel plates under a specific load for a specific time. The load is removed and the compressed strands are allowed to recover. The measurements are replicated 10 times with fresh strands each time. The entire test, including cooking is repeated again. From the average of the readings, the firmness (F) and elastic recovery (ER) are calculated as :

$$F, (\%) = [e_1 / e] \times 100$$

$$ER, (\%) = [(e_2 - e_1) / (e - e_1)] \times 100$$

Where e = thickness of strands (mm) before compression

e_1 = thickness of strands (mm) after compression and

e_2 = thickness of strands (mm) after recovery.

Adhesion tests for cooked pasta products typically involve compression of a test specimen between two flat platens and measurement of the force or work required to separate the upper platen from the specimen (Cole 1991).

Tsuji (1982) developed and applied a modified texture profile analysis (TPA) system using Tensipresser for noodle dough and cooked noodles. He applied multi-point mensuration method, which is a form of TPA which uses several variable degrees of compressions or bites and showed that the type of compressing or biting plunger plays an important role in the shape of the TPA curve.

Packaging and storage

Packaging of noodles is necessary to keep the product free from contamination, damage during transport and storage and displaying the product favourably for consumer appeal. Cellophane is used primarily for packing of noodles. It provides clarity as well as protection against insect and moisture. Low density polyethylene bags are often used for packaging pasta products. These offer the same protection but do not have the clarity of the cellophane and also have the disadvantage of being difficult to stack on supermarket shelves. Many U.S. pasta manufacturers prefer to pack their products in cardboard boxes since they are easy to stack, provide good physical protection for the product and advertising is easier to print and read on boxes than plastic containers (Donnelly 1991).

Sowbhagya et al (2000) prepared maize vermicelli noodles with and without antioxidant (tertiary butylhydroquinone, TBHQ) and packed in cast polypropylene (cpp) and a laminate of metallised polyester with low density polyethylene (M-PET/PE). The packs were stored at 38°C, 92% RH (accelerated storage) and 27°C, 65% RH (normal storage) for 100 to 140 days. Solid loss of the product upon cooking decreased from 12.4 to 7.6% at accelerated storage and to 9.6% at normal storage. Firmness and elasticity of the cooked product, however, increased upon storage. The sensory properties of the cooked product remained good up to 100 days at both the storage and packaging conditions.

Future scenario

Noodles and pasta, in spite of their ancient origins, have undergone considerable evolution and migration as the products become increasingly globalised. There is phenomenal growth in the consumption of 'fresh' pasta, in recent times on account of consumer perception of a better quality for them and as preparation of final product is much quicker. An annual increase of 5-10% has been reported in Germany, France and Italy in the consumption of 'fresh' pasta products (Seibel 1996). A strict quality control during processing, packaging and storage is however necessary due to its high moisture content. Fresh pasta from the extrusion press has approximately 30-60% moisture. Many fresh pastas are sold unpacked with no labeling requirements as do the dry packaged product. Perhaps fresh vermicelli noodles have lot of scope in the Indian situation as the cost will come down drastically, and affordable. The southern part of India is very familiar to rice vermicelli noodles which is normally made and consumed fresh. Wheat noodles / vermicelli are very familiar throughout India and are available under different trade names. Vetrimani and Rahim (1994) have evaluated the quality of some of the commercial brands of wheat noodles in Indian market and found that the products manufactured by organised sector (medium / large industry) had better overall quality, with low (<10%) solid loss during test cooking and better appearance, texture and flavour of cooked noodles in comparison to those produced by the cottage / small scale sector. Of late, dried rice noodles / vermicelli are appearing in the market. Noodles from maize and other millets like finger millet, pearl millet, sorghum, etc are still to appear in the market. Since people are becoming very health conscious and want high fibre low fat content in their diet, the noodles from millets have a great future, since they contain high fibre and low fat. Lot of scope also exists for fortification of noodles / vermicelli with minerals, vitamins and proteins from other vegetable sources like pulses, groundnut and soybean, to increase their nutritive value. A huge potential exists for these products, as it is a value added and convenient product for the manufacture as well as for the working women community. It also adds variety for the consumers. The product can be used as a savory or sweet food; it can be used as a snack dish after frying. These products from other cereals and millets (other than rice and wheat) have a good export potential especially to Middle East, Australia and Europe beside the good internal market.

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RESEARCH PAPER

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Studies on Bitterness Development in Kinnow Juice, Ready-to-Serve Beverage, Squash, Jam and Candy

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Kinnow juice kept at 5-70°C, showed that development of bitterness increased with rise in temperature. Ready-to-Serve beverage and squash prepared by incorporating the juice into syrup did not show bitterness development. Jam made from lye peeled segment did not develop bitterness whereas unpeeled segment developed bitterness. Candied segment did not show any development of bitterness.

Keywords : Kinnow, Juice, Ready-to-Serve beverage, Squash, Jam, Candy, Lye peeling.

Mandarins are the most popular citrus fruits grown in northern India and among the mandarins, Kinnow (*Citrus nobilis* X *Citrus deliciosa*) is the most important. It is widely grown in Punjab with 27.5 thousand hectare area and 275 thousand tonnes production in 1998 (Department of Horticulture, Punjab). It has got excellent organoleptic and nutrition value. It is highly refreshing with pleasant taste and aroma. It is a good source of β-carotene, vitamin C, calcium and phosphorus. This fruit is generally consumed either for table purposes or in the form of juice. Fruit juice vendors sell its juice immediately after expression before the bitterness could develop. The processing of the fruit into various products is limited because of the development of bitterness during handling.

The bitterness is primarily caused by conversion of limonate-a-ring lactone (non-bitter precursor) to limonin in the presence of air. It is purely a chemical reaction which is accelerated by heat (Premi et al. 1994). Another major compound responsible for bitterness is naringin. The limonin and naringin content varies in different parts of the fruit. The seed contains the highest quantity of limonin (9.5 mg/g), followed by peel (4.69 mg/g) and juice (0.218 mg/ml). Where as naringin content is highest in peel (0.42 mg/g), followed by juice (0.23 mg/g) and seed (0.134 mg/g) (Premi et al. 1994).

Different workers have suggested several methods to control the bitterness in kinnow juice i.e. raising pH of juice (Renote and Bains 1982), adding sweetening agent (Guadagni et al. 1974), using adsorbent XAD-16 (Premi et al. 1995, Wilson et al. 1989), adding β-cyclodextrin monomers for forming inclusion complexes of limonin (Konno et al. 1981) and converting bitter principle to non bitter compounds by the action of immobilized bacteria (Maier et al. 1983). Among these methods, only the use of resins (XAD-16) is employed commercially in processing industry. This technique is labour intensive and time consuming since the resins are required to be reactivated. Present investigation was conducted to alter the process conditions of various kinnow products to control bitterness development.

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Materials and Methods

Materials : Kinnows were procured from the local market during December 1996.

Juice : Kinnows were peeled manually and the juice was obtained using screw press (Kalsi Gears, India). The juice was stored at various temperatures i.e. refrigerated (3-6°C), ambient (13-16°C), 30°C, 50°C, and 70°C and tasted at hourly interval to judge the development of bitterness.

Ready-to-Serve (RTS) beverage : Juice was collected in a vessel containing syrup, then it was filtered with muslin cloth and mixed with other ingredients. The products were packed in air tight glass bottles and stored at ambient (16-20°C) as well as elevated temperature (38°C).

Squash : This was prepared from kinnow in the similar manner like RTS beverage but quantities of ingredients were changed. The product was also packed in air tight glass bottles and stored at ambient (16-20°C) as well as evlevated temperature (38°C).

Lye peeling of segments : Kinnows were peeled and segments were separated manually. The segments were treated with 0.5-2.5 % NaOH for 2-5 min at 95 ± 2°C. After cooling in running tap water, the remaining alkali was neutralised by dipping in 1 % citric acid solution. Conditions were optimised based on the extent of peel removed, colour and number of brokens.

Jam : Segments were passed through pulper, equal amount of sugar was added and pH was adjusted to 3.1. It was concentrated to 70°Brix, packed hot in air tight glass jars and stored under ambient condition (16-20°C).

Candy : Segments were kept in 30°Brix syrup and cooked slowly to 80°Brix. After draining the syrup, segments were dried at 55°C for 5 h and then coated with powdered sugar. Product was packed in polyethylene pouches and kept at ambient temperature (16-20°C).

Physico-chemical analysis : The products were analysed during the storage period at 30 days interval. The total soluble solids (TSS) of the samples were recorded using Abbe-Refractometer (Milton Roy Co., USA) at 20 ± 1°C. The pH was

measured using pH meter (Naina Portable Kit NPC 360 D). The titrable acidity, reducing sugars, total sugars and ascorbic acid were determined according to Ranganna (1986).

Sensory analysis : The products were evaluated at fortnightly intervals by a panel of fifteen semi-trained members using a 9 point Hedonic scale, for colour, flavour and overall acceptability. The bitterness was evaluated on the basis of perception and expressed as follows: completely bitter (+ +), slightly bitter (+) and non bitter (-). In lye peeling the colour score was evaluated using three point scale i.e. good-1, very good-2 and excellent-3.

Statistical analysis : Analysis of Variance (ANOVA), Least Significant Difference (lsd) and Regression Correlation Analysis were carried out according to Gomez and Gomez (1984) using Microsoft Excel 97.

Results and Discussion

Kinnow juice : Kinnow juice was analysed for its proximate composition. Results revealed that TSS was 10.2°Brix as compared to 13.5°Brix reported by Renote et al (1993). The pH value was observed to be 3.42, which was also lower than reported by the same authors. The acidity, reducing sugars and total sugars were 0.97 %, 3.42 % and 6.84 %, respectively. Reducing sugars content was found to be more than the reported value of 3.29 % and total sugars content was lower than the reported value of 6.98 %. Ascorbic acid content was found to be 20.53 mg/100 g, agreeing with the reported value.

Study was carried out immediately after juice expression, to know the time lapse in bitterness development at different temperatures (Fig. 1). The bitterness was observed by tasting the juice at hourly intervals. Juice under ambient condition (13-16°C) showed no bitterness up to 5 h. After 6 h, a slight and after 9 h, complete bitterness was observed. At 30°C, juice remained non-bitter upto 3 h and after 4h, bitterness was fully developed. Juice incubated at 50°C, remained non-bitter up to 2 h, but cooked flavour developed. After 3 h, bitterness was observed along with cooked flavour. Kinnow juice kept at 70°C showed complete bitterness along with cooked flavour after 1 h of incubation.

The relationship between temperature and bitterness development was established by Non-linear Regression

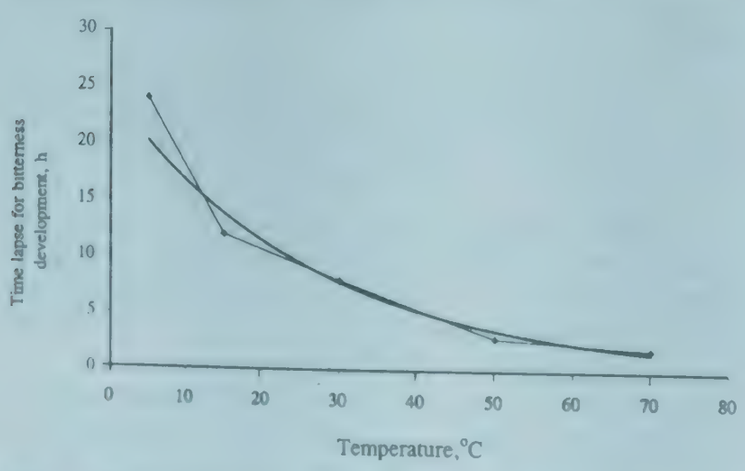

Fig. 1. Effect of temperature and time on bitterness development in kinnow juice

TABLE 1. EFFECT OF STORAGE ON PHYSICO-CHEMICAL CHARACTERISTICS OF RTS BEVERAGE

Storage period, days	TSS, °B	Acidity, %	pH	Total sugars, %	Reducing sugars, %	Ascorbic acid, mg %
Ambient temperature (16-20°C)						
0	11.2^{a}	0.39^{a}	3.00^{a}	8.43^{a}	1.57^{a}	5.99^{a}
30	11.2^{a}	0.42^{b}	2.98^{a}	8.57^{b}	1.60^{a}	4.29^{b}
60	11.2^{a}	0.45^{c}	2.92^{a}	9.22^{c}	2.10^{b}	4.21^{c}
90	11.2^{a}	0.49^{d}	2.83^{b}	9.50^{d}	2.53^{c}	4.13^{d}
120	11.3^{b}	0.51^{e}	2.77^{b}	10.21^{e}	2.90^{d}	4.08^{e}
lsd (p<0.05)	0.001	0.02	0.09	0.05	0.22	0.03
Elevated temperature (38°C)						
0	11.2^{a}	0.39^{a}	3.00^{a}	8.43^{a}	1.57^{a}	5.99^{a}
30	11.4^{b}	0.41^{b}	3.05^{b}	8.57^{b}	1.60^{b}	3.01^{b}
60	11.4^{b}	0.47^{c}	2.95^{b}	9.35^{c}	2.13^{c}	2.97^{b}
90	11.3^{c}	0.51^{d}	2.82^{c}	9.63^{d}	2.98^{d}	2.90^{c}
120	11.4^{b}	0.57^{e}	2.75^{d}	10.05^{e}	3.53^{e}	2.88^{c}
lsd (p<0.05)	0.003	0.02	0.03	0.05	0.03	0.04

Means not sharing common superscript letter in a column are significantly different

Analysis. Results showed that the effect of temperature can be explained by exponential model as follows.

$$Y = 25.304e^{-0.047oX}$$

Where X = Temperature (°C)

Y = Time lapse for bitterness development (h)

Correlation analysis showed that 98.8 % of the predicted values agreed with the observed values.

Kinnow RTS beverage : The RTS beverage was prepared by the method described earlier and stored at ambient (16-20°C) as well as elevated temperatures (38°C) for 120 days (Table 1). The physical analysis carried out at 30 days interval revealed that the TSS of beverage remained almost unchanged, while titrable acidity increased. This increase may be due to release of acid from the pulp particles due to autolysis of the cells. The pH of RTS decreased with storage which corresponded to the increase in acidity. There was an increase in acidity as well as total sugars. The increase in reducing sugars could be due to inversion of sucrose to glucose and fructose or breakdown of polysaccharides into simple sugars. Ascorbic acid content decreased from an initial value of 5.99 to 4.08 mg/100 µg at amibient and from 5.99 to 2.8 mg/100 g at elevated temperatures. The loss of ascorbic acid could be attributed to oxidation due to light and storage temperature. The higher storage temperature was found to affect the ascorbic acid content. Statistical analysis using ANOVA, showed that there was a significant difference among the observed value over the storage period. The lsd showed significant change at 5 % level of significance after each time interval.

The panelists did not perceive any bitterness in RTS stored at ambient as well as elevated temperatures (Table 2). The sensory scores indicated that the products had desirable bright yellow colour at ambient than at elevated temperature. Non-enzymatic browning at elevated temperatures might have made the colour dull and dark. Initially, flavour of the RTS

TABLE 2. EFFECT OF STORAGE ON SENSORY CHARACTERISTICS OF RTS BEVERAGE

Sensory characteristics	Storage period, days 0	15	30	45	60	75	90	105	120	135
Ambient temperature (16-20°C)										
Bitterness	-	-	-	-	-	-	-	-	-	-
Colour	6.86 ± 0.83	6.66 ± 0.81	6.53 ± 0.74	6.37 ± 0.95	6.23 ± 1.05	6.06 ± 0.88	6.24 ± 0.86	6.00 ± 0.65	5.53 ± 0.91	5.40 ± 0.55
Flavour	7.00 ± 0.65	6.93 ± 0.88	6.86 ± 0.45	6.66 ± 0.97	5.73 ± 0.88	5.62 ± 0.71	5.66 ± 1.04	5.26 ± 0.70	5.22 ± 0.67	5.33 ± 0.61
O.A.	7.20 ± 0.67	7.00 ± 0.84	6.73 ± 0.79	6.53 ± 0.83	6.21 ± 0.94	6.00 ± 0.92	5.86 ± 0.63	5.73 ± 0.59	5.64 ± 0.63	5.46 ± 0.88
Elevated temperature (38°C)										
Bitterness	-	-	-	-	-	-	-	-	-	-
Colour	6.86 ± 0.83	6.50 ± 0.85	5.86 ± 0.74	5.53 ± 0.74	5.13 ± 0.85	5.28 ± 0.67	4.86 ± 0.74	4.75 ± 0.88	4.66 ± 0.88	4.60 ± 0.55
Flavour	7.00 ± 0.65	6.64 ± 0.95	5.66 ± 0.85	5.26 ± 0.88	4.42 ± 0.73	4.26 ± 0.70	4.13 ± 0.85	4.01 ± 0.84	3.81 ± 0.67	3.38 ± 0.72
O.A.	7.20 ± 0.67	6.61 ± 0.79	5.46 ± 0.91	5.22 ± 0.77	5.13 ± 0.74	5.06 ± 0.79	4.46 ± 0.74	4.33 ± 0.89	4.33 ± 0.81	4.26 ± 0.70

(-) No bitterness, (+) Slight bitterness, (+ +) Complete bitterness
O.A. - Overall acceptability

beverage was liked very much and received good scores but slight cooked flavour was observed after one month of storage at elevated temperature. Higher temperature might have facilitated various chemical changes contributing cooked flavour. The flavour scores decreased after 45 days in products kept at room temperature as compared to 30 days at elevated temperature. The flavour remained acceptable during the entire period at ambient temperature, while at elevated temperatures it got low scores. It might be due to various changes that took place in the limonin content, which affected taste. The overall acceptability of RTS beverage was quite high in the beginning but declined as storage progressed. This decline in score was more pronounced at elevated temperature as compared to ambient due to changes in colour and flavour.

Kinnow squash : The physico-chemical analysis of squash showed an insignificant change in TSS and increase in acidity (Table 3). The change in acidity was similar in both samples stored at ambient as well as elevated temperatures. This indicated that it was not affected by the storage temperature. There was a gradual decline in pH but increase in total and reducing sugars as storage progressed with higher change at elevated as compared to ambient temperature. This may be due to breakdown of complex polysaccharides into simple sugars at elevated temperature. There was a significant reduction in ascorbic acid content with storage. The decline in ascorbic acid content was more at elevated temperature. The initial ascorbic acid 20.30 mg/100 g was reduced to 9.48 mg/100 g at elevated temperature compared to 13.68 mg/100 g at ambient. The ANOVA and lsd ($p<0.05$) showed significant changes among the observed value due to storage.

The sensory scores indicated that there was no bitterness developed in squash at either temperature, but a slight off flavour was noticed in squash stored at elevated temperature (Table 4). The sensory scores declined with storage. This trend was more pronounced at elevated temperature than at ambient one. At the ambient temperature the colour score decreased slightly from 7.4 to 6.8 at the end of 135 days. The flavour and overall acceptability score decreased from 7.2 to 6.1 and 7.2 to 6.9, respectively. The sensory score of squash

TABLE 3. EFFECT OF STORAGE ON PHYSICO-CHEMICAL CHARACTERISTICS OF SQUASH

Storage period, days	TSS, °B	Acidity, %	pH	Total sugars, %	Reducing sugars, %	Ascorbic acid, mg %
Ambient temperature (16-20°C)						
0	41.8^{a}	1.49^{a}	2.61^{a}	32.95^{a}	3.27^{a}	20.30^{a}
30	42.0^{b}	1.56^{b}	2.50^{b}	35.36^{b}	3.28^{a}	15.37^{b}
60	42.1^{c}	1.63^{c}	2.45^{c}	35.82^{c}	3.68^{c}	15.05^{c}
90	42.0^{b}	1.70^{d}	2.39^{d}	36.52^{d}	4.05^{c}	14.37^{d}
120	42.0^{b}	1.75^{e}	2.34^{e}	37.21^{e}	4.57^{d}	13.68^{e}
lsd ($p<0.05$)	0.05	0.02	0.02	0.17	0.02	0.04
Elevated temperature (38°C)						
0	41.8^{a}	1.49^{a}	2.61^{a}	32.95^{a}	3.27^{a}	20.30^{a}
30	42.2^{b}	1.56^{b}	2.52^{b}	35.36^{b}	3.28^{a}	14.37^{b}
60	42.1^{c}	1.63^{c}	2.43^{c}	36.15^{c}	3.73^{b}	12.23^{c}
90	42.2^{d}	1.70^{d}	2.40^{c}	36.92^{d}	4.25^{c}	10.83^{d}
120	42.2^{d}	1.75^{e}	2.35^{d}	37.83^{e}	4.80^{d}	9.48^{e}
lsd ($p<0.05$)	0.09	0.02	0.04	0.02	0.04	0.05

Means not sharing common superscript letter in a column are significantly different

stored at elevated temperature showed a reduction in colour, flavour and overall acceptability scores from 7.4 to 5.43, 7.2 to 5.6 and 7.2 to 5.9 respectively during 135 days of storage.

Standardisation of lye peeling : A study was undertaken to find the effect of alkali strength, temperature and duration of treatments on peeling efficiency in term of colour, peel removal and breakage of segments (Fig. 2 and 3). The results indicated that 0.5 % lye strength at 95 ± 2°C did not peel segments properly up to 2 min. However, after 2.5 min the peeling was proper but breakage was higher and colour was not appealing. Lye concentration of 1 % gave proper peeling with one minute treatment. However, higher concentration of lye affected the colour and increased duration of treatments increased number of broken segments. Results revealed that there was no breakage of segments, when heated up to 1.5 min at all lye concentration except for 2.5 %, where one broken segment was observed. Number of broken segment

TABLE 4 EFFECT OF STORAGE ON SENSORY CHARACTERISTICS OF SQUASH

Sensory characteristics	Storage period, days 0	15	30	45	60	75	90	105	120	135
Ambient temperature (16-20°C)										
Bitterness	-	-	-	-	-	-	-	-	-	-
Colour	7.40 ± 0.88	7.02 ± 1.01	7.13 ± 1.24	7.26 ± 1.03	7.21 ± 1.14	7.41 ± 1.05	6.92 ± 0.88	7.06 ± 1.03	6.86 ± 0.83	6.80 ± 0.86
Flavour	7.20 ± 1.01	6.81 ± 1.12	7.02 ± 1.00	7.13 ± 1.18	6.66 ± 1.11	6.61 ± 0.82	6.74 ± 0.88	6.43 ± 0.83	6.80 ± 0.77	6.13 ± 0.83
O.A.	7.20 ± 0.88	7.41 ± 0.83	7.25 ± 1.06	7.33 ± 0.90	7.32 ± 0.83	7.41 ± 0.45	7.34 ± 0.72	6.90 ± 1.03	7.13 ± 0.91	6.93 ± 0.16
Elevated temperature (38°C)										
Bitterness	-	-	-	-	-	-	-	-	-	-
Colour	7.40 ± 0.88	6.72 ± 0.79	6.85 ± 0.86	6.73 ± 0.71	6.53 ± 0.83	6.60 ± 0.91	6.42 ± 0.73	6.86 ± 0.67	5.97 ± 0.68	5.43 ± 0.62
Flavour	7.20 ± 1.05	6.75 ± 0.88	6.21 ± 0.77	6.46 ± 0.63	6.06 ± 0.88	5.80 ± 0.77	5.93 ± 0.96	6.06 ± 0.79	5.66 ± 0.83	5.63 ± 0.95
O.A.	7.22 ± 0.88	6.91 ± 0.96	6.81 ± 0.75	6.80 ± 1.08	6.80 ± 0.67	6.41 ± 0.75	6.06 ± 0.70	6.26 ± 0.59	6.13 ± 0.91	5.93 ± 0.77

(-) No bitterness, (+) Slight bitterness, (+ +) Complete bitterness
O.A. - Overall acceptability

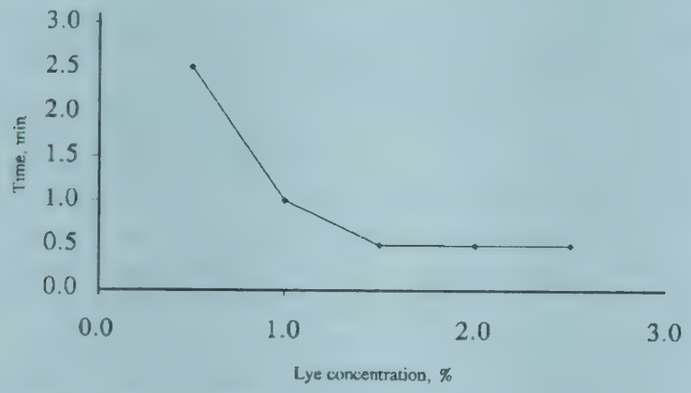

Fig. 2. Time required for adequate peeling of kinnow segments

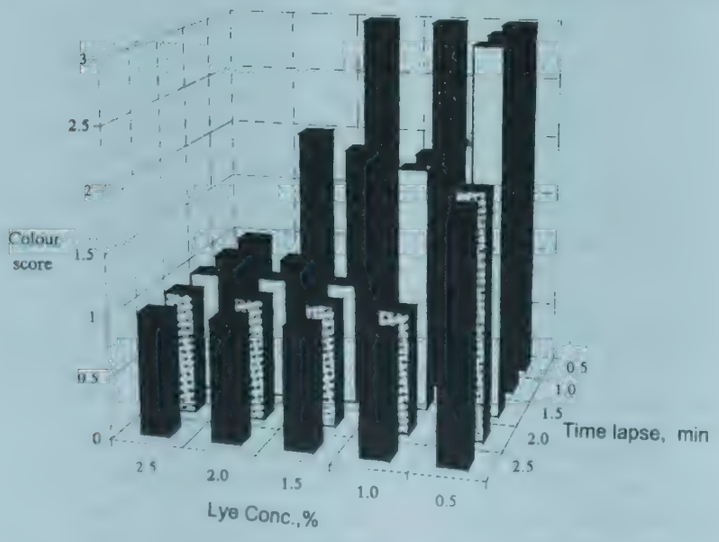

Fig. 3. Effect of lye concentration and heating time on colour score of kinoow segments

varied from 1 to 4 when heated for 2 and 2.5 min. at all lye concentrations. The data also revealed that colour deterioration followed a pattern but the broken segments did not. Therefore, optimum condition for peeling was 1 % NaOH at 95 ± 2°C for 1.0-1.5 min.

Kinnow jam : Storage studies revealed that jam made from unpeeled and lye peeled segments, showed marginal increase in TSS (Table 5). It may be due to loss of moisture as a result of repeated opening and closing the container to draw sample for analysis. Acidity increased from 1.53 to 1.75 and 1.34 to 1.50 % at the end of 90 days storage. There was an increase in total and reducing sugar contents on storage. The increase in reducing sugar contents may be due to inversion of sucrose, where as the increase in total sugar content can be attributed to the breakdown of polysaccharides to simple sugars. The ascorbic acid contents decreased with storage from initial value 34.06 to 29.41 and 26.33 to 24.09 mg/100 g due to oxidation. The ANOVA and lsd ($p<0.05$) showed significant changes among the observed value due to storage.

The sensory data showed that the panelists did not report bitterness even at the end of 105 days storage (Table 6). However, in case of jam from unpeeled segments, there was no development of bitterness upto 30 days, slight bitterness after 45 days and intensity increased later. The bitterness

TABLE 5. EFFECT OF STORAGE ON CHEMICAL CHARACTERISTICS OF JAM UNDER AMBIENT CONDITION (16-20°C)

Storage period, days	TSS, °B	Acidity, %	Total sugars, %	Reducing sugars, %	Ascorbic acid, mg %
Without peeling					
0	70.0^a	1.53^a	61.05^a	3.02^a	34.06^a
30	71.5^b	1.59^b	62.93^b	3.52^b	32.85^b
60	72.0^c	1.68^c	63.21^c	4.11^c	31.35^c
90	72.0^c	1.75^d	63.83^d	4.23^d	29.41^d
lsd ($p<0.05$)	0.23	0.01	0.08	0.03	0.08
Lye peeling					
0	70.0^a	1.34^a	61.05^a	3.02^a	26.33^a
30	72.0^b	1.40^b	63.20^b	3.98^b	26.87^b
60	72.0^b	1.53^c	64.11^c	4.52^c	25.37^c
90	72.4^c	1.51^c	64.85^d	4.83^d	24.09^d
lsd ($p<0.05$)	0.23	0.02	0.19	0.04	0.20

Means not sharing common superscript letter in a column are significantly different

TABLE 6. EFFECT OF STORAGE ON SENSORY CHARACTERISTICS OF JAM UNDER AMBIENT CONDITION (16-20°C)

Sensory characteristics	Storage period, days 0	15	30	45	60	75	90	105
Without peeling								
Bitterness	-	-	-	+	+	+ +	+ +	+ +
Colour	7.20 ± 0.94	7.13 ± 0.88	7.06 ± 0.92	6.85 ± 0.88	6.52 ± 0.91	6.45 ± 0.63	6.10 ± 0.76	5.75 ± 0.63
Flavour	7.46 ± 0.63	7.38 ± 0.65	6.45 ± 0.78	6.13 ± 0.91	6.08 ± 0.52	5.45 ± 0.91	4.86 ± 0.63	4.75 ± 0.73
O.A.	7.66 ± 0.66	7.40 ± 0.85	7.37 ± 0.89	6.86 ± 0.48	6.53 ± 1.05	6.06 ± 0.70	5.58 ± 0.73	5.43 ± 0.62
Lye peeling								
Bitterness	-	-	-	-	-	-	-	-
Colour	8.13 ± 0.74	8.12 ± 0.80	7.80 ± 0.67	7.73 ± 0.88	7.53 ± 0.63	7.46 ± 0.74	7.50 ± 0.70	7.50 ± 0.75
Flavour	8.33 ± 0.61	8.21 ± 0.67	7.90 ± 0.82	7.40 ± 0.91	7.13 ± 0.91	7.06 ± 0.70	6.93 ± 0.59	6.86 ± 0.74
O.A.	8.33 ± 0.72	8.26 ± 0.70	8.06 ± 0.59	8.00 ± 0.65	7.80 ± 0.67	7.56 ± 0.72	7.40 ± 0.73	7.13 ± 0.74

(-) No bitterness, (+) Slight bitterness, (+ +) Complete bitterness
O.A. - Overall acceptability

might be developed due to conversion of limonate-a-ring lactone to limonin. The conversion was very slow in initial stages and crossed the threshold level after 45 days of storage. Bitterness was fully developed at the end of 75 days of storage at ambient temperature. The colour score was also good in jam from lye peeled segments. However, there was a slight decline in colour score, which could be attributed to non-enzymatic browning. The flavour and overall acceptability scores were also affected during storage.

Kinnow candy : The candy showed very high TSS due to sugar coat (Table 7). The TSS of candy increased due to drying as it was not packed in an air tight container. The acidity increased from the initial value of 0.65 to 0.70 %. The total sugars increased due to breakdown of complex sugars. The reducing sugars contents increased due to inversion of sucrose. Ascorbic acid content decreased from the initial value of 18.34 to 10.68 mg/100 g which may due to oxidation. The ANOVA and lsd ($p<0.05$) showed significant changes among the observed values due to storage. The sensory analysis indicated no development of bitterness even after 90 days of storage (Table 8). There was decline in colour score, which might be due to increase in dullness. Flavour score remained almost uniform. The overall acceptability score slightly decreased which may be due to change in colour and appearance.

TABLE 7. EFFECT OF STORAGE ON CHEMICAL CHARACTERISTICS OF CANDY UNDER AMBIENT CONDITION (16-20°C)

Storage period, days	TSS, °B	Acidity, %	Total sugars, %	Reducing sugars, %	Ascorbic acid, mg %
0	83.5[a]	0.65[a]	63.45[a]	2.82[a]	18.34[a]
30	84.2[b]	0.67[b]	63.83[b]	2.94[b]	15.24[b]
60	84.8[c]	0.69[c]	64.24[c]	3.10[b]	12.10[c]
90	85.5[d]	0.70[c]	65.90[d]	3.18[b]	10.68[d]
lsd ($p<0.05$)	0.09	0.02	0.10	0.11	0.14

Means not sharing common superscript letter in a column are significantly different

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TABLE 8. EFFECT OF STORAGE ON SENSORY CHARACTERISTICS OF CANDY UNDER AMBIENT CONDITION (16-20°C)

Sensory characteristics	Storage period, days 0	15	30	45	60	75	90
Without peeling							
Bitterness	-	-	-	-	-	-	-
Colour	7.60 ± 0.58	7.56 ± 0.62	7.20 ± 0.86	7.13 ± 0.80	7.00 ± 0.70	6.73 ± 0.79	5.06 ± 0.79
Flavour	7.8 0 ± 0.67	7.73 ± 0.59	6.82 ± 0.67	6.68 ± 0.70	7.33 ± 0.81	6.13 ± 0.83	5.80 ± 0.77
O.A.	7.73 ± 0.70	7.66 ± 0.72	7.20 ± 0.67	7.13 ± 0.74	7.12 ± 0.80	7.06 ± 0.70	6.80 ± 0.58

(-) No bitterness, (+) Slight bitterness, (+ +) Complete bitterness
O.A. - Overall acceptability

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RESEARCH PAPER

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Artificial Neural Network Simulation of Ball and Stumbo Formula Methods of Thermal Process Calculations

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Application of Artificial Neural Network (ANN) models to simulate Ball and Stumbo methods of thermal process calculations is presented in this study. ANN models were developed based on relating Ball and Stumbo table parameters to facilitate process calculations. The ANN models related g value (as a measure of process time) to f_h/U (as a measure of process lethality). Tables developed by Stumbo accommodate the j_{cc} (cooling lag factor) while relating g and f_h/U, therefore, for developing ANN models of Stumbo method, j_{cc} was considered as an additional input variable. The developed ANN models for Ball and Stumbo methods were validated using a new set of processing conditions, involving a range of retort temperatures, initial temperatures, heating rates and heating lag factors [and additionally, for Stumbo method cooling lag factors (j_{cc})]. The prediction efficiency of ANN models were a function of the size of training data set, number of hidden layers and PEs in each hidden layer as well as other learning parameters. ANN based Ball models had an average error of 1 % for the validation data set while the ANN based Stumbo models had a bit higher 3 % average error for process time and process lethality calculations. The smaller number of data sets and a wider range of parameters associated with Stumbo tables were considered to be the reason for the associated higher errors with the ANN-based Stumbo models. In general, the ANN models were considered to well simulate Ball and Stumbo methods of process calculations providing a basis for further exploration of the concept.

Keywords : Thermal processing, Process calculations, Ball method, Stumbo method, Artificial neural network, Modelling.

Thermal processing of packaged foods is one of the most widely used methods of preservation in twentieth century (Teixeira and Tucker 1997). Nicholos Appert introduced this method for the first time in 1810. The concept of thermal processing is based on heating of packaged foods for a certain length of time to obtain a safe product complying with public health standards. Thermal processing is based on established time-temperature profiles. Associated with thermal processing is always some degradation of heat-sensitive quality factors that is undesirable. Since much demand is on safe and shelf-stable food products along with a high quality attributes, processing schedules are designed to keep the process time to the required minimum.

The main objective of thermal process calculations is to determine the process time for achieving a pre-selected process lethality or evaluating the lethality of a given process. For the first time, Bigelow et al (1920) introduced a graphical procedure of evaluating the efficiency of heat treatment process for packaged foods. Ball (1923) refined the concept and developed a mathematical model (referred to as Ball method) for calculating the required process time of canned foods. Besides some limitations in this method, the Ball method is considered a milestone in canning industry and still is a widely used method in industry. This method is positioned as a classical tribute to the value of mathematics in food processing.

Ball method is based on the observation that a semi-logarithmic graph of temperature difference between product and medium vs. time is a straight line after an initial curved portion (lag time). Ball (1923) calculated the process time based on the equation of this straight line and integrating the effect of process time over the kinetic data of microbial destruction. Usually the effect of curved portion of heating is not considered, as the lethal effect of this portion is negligible compare to total achieved lethality. However the conditions of high initial temperature, large z-vales or processing for low required lethality, the efficiency of this portion of heating should be taken into consideration.

The estimation of proper heat processes is essentially based on the calculation of process lethality, *Fo,* computed as follows :

$$Fo = \int_0^t 10^{\frac{T_{ref}-T}{z}} dt \quad \ldots\ldots (1)$$

where T_{ref} is the reference temperature, T is the center point temperature, and z is the temperature sensitivity indicator of F value.

For low acid food products, 250°F (121.1°C) is widely used as a reference temperature. Ball developed tables and graphs to relate process time and process lethality. These tables and graphs were based on relating two parameters; g (temperature difference between product and heating medium at the end of heating) as a measure of process time to f_h/U (ratio of heating rate to sterilization value) as the measure of process lethality. Some restrictive assumptions were made during the development of these tables and graphs. One of the most important one, which can sometimes cause errors in calculations, was a constant cooling lag factor, j_{cc} value, equal to 1.41. Therefore, Ball method overestimates process lethality when j_{cc}<1.41 and underestimates when j_{cc}>1.41 (Ball and Olson 1957; Hayakawa 1978). Also Ball (1923) assumed an equal heating and cooling rate (f_h=f_c). In practice, the values of these two parameters differ from each other. It has been found that for steam heating and water cooling f_c-1.3f_h (Pham 1990) and obviously disregarding this inequity interferes with the accuracy of process calculations. Ball method has

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been widely reviewed and evaluated by several researchers (Merson et al. 1978; Flambert et al. 1977; Steele and Board 1979; Spinak and Wiley 1982; Stoforos 1991).

Stumbo and Longley (1966) reviewed and revised tables developed by Ball (1923). The variability of j_{cc} value was considered in these tables for more reliable and accurate thermal processes calculations (Stumbo 1973). These tables are obtained from hand drawn heat-penetration curves and relate f_h/U and g values with respect to variability of j_{cc}. Also the variability of f_h and f_c was considered in developing these tables, but it applies only to cases, where the difference of f_h and f_c is not more than 20 % of respective f_h value (Hayakawa 1978; Stoforos et al. 1997).

Artificial neural network models

Artificial neural network (ANN) models are computational models made up of several processing elements (PEs), which are connected through weighted links. Development of model is basically based on adjusting the weights through presenting adequate number of examples consisting of input and output variable pairs.

Generally, ANN models are constructed from an input layer, an output layer and one or more hidden layer (s). Input layer transfers the information to the network for processing. Output layer receives the processed information and sends it to external receptor. Hidden layers process the received information from input layer, extracts the existing features in input variables and predict an output. Among different networks, back-propagation networks, back-propagation network has the most applicability in prediction and classification problems. Back-propagation network is a feed-forward network, which propagates back a portion of error between desired and ANN predicted output to correct the weight parameters.

Recently, ANNs have shown a potential for applications in food science and technology areas. Eerikainen et al (1993) presented a series of examples of potential application of ANN models in food-related applications. Parmer et al (1997) applied neural network modeling for estimation of aflatoxin contamination in peanuts which performed better than traditional linear regression techniques. Ni and Gunasekaran (1998) simulated the complex task of food quality prediction using ANN models. Boucherau et al (1990) developed a neural-network-based method for prediction of apple juice quality using near infrared spectra. Neural networks were used to determine the significant variables in harvesting and processing effects on Surimi quality by Peters et al (1996). Kim and Cho (1997) developed an ANN model for the bread baking process, using three quality factors of volume, browning and temperature. In thermal processing, Sablani et al (1995) applied neural network models to predict optimum thermal processing conditions. As an application in drying, Sreekanth et al (1998) developed an ANN model for prediction of psychometric parameters.

The global objective of this study was to evaluate the potential of ANN models as an alternative to conventional process calculation methods. As a first step in this direction, data from two classical methods: Ball and Stumbo methods were used to develop the models and assess their performance. Hence, the main objective of this work was to study ANN simulation of Ball and Stumbo methods of process calculations.

Materials and Methods

ANN modelling of Ball and Stumbo methods

Ball and Stumbo methods relate process time and process lethality by relating two parameter, g and f_h/U, in the form of tables or graphs. In tables developed by Stumbo, the effect of j_{cc} on this relation is also considered. For a known process time along with the other processing conditions, g value will be known; alternatively for a given process lethality, f_h/U will be known. For developing ANN-based process calculation models, Ball and Stumbo methods were simulated based on relating the parameters of these tables. Data (f_h/U vs. g or g vs. f_h/u) for both training and verification were obtained from tables published in Lopez (1987) for Ball method and Stumbo (1973) for Stumbo method. Detailed tables were available in Lopez (1987) and hence 1050 data pairs were used in Ball model for training. For Stumbo method, only 44 data sets were available relating f_h/U vs. g (and vice versa) at 9 different values of j_{cc}. A z-value of 10°C was used for both models. For each method, two models were developed one for predicting f_h/U based on g and *vice versa*.

Development of ANN models

Ball method : Neural Works Professional II/Plus, version 5.23 (Neural Ware Inc., Pittsburgh, PA) was employed for ANN modeling. A standard back-propagation algorithm with tangent hyperbolic transfer function and normalized cumulative delta learning rule was applied as the basic architecture of network. As the input and output variables were changing over a wide range, for a better presentation of input and outputs to the network and a more uniform data set, a mathematical transform function was applied. Therefore, *log g* was predicted from *log* (f_h/U), and f_h/U in the form of *arctangent* (*log* f_h/U) was predicted from *log g*. For a more convenient recalling of models, from now prediction of *log g* will be denoted, as Model A and prediction of f_h/U will be denoted as Model B.

It has been recognized that the network predictability and performance should be optimized with respect to size of the training data set, structure of the network, number of hidden layers, number of processing elements in the hidden layer, type of learning rule and transfer function. Several other variables also affect the ANN model development and performance. Among them momentum and epoch size have the most significant effect on the network performance. The momentum represents a fractional value from the previous weight change added to the present weight correction. Its value can change between 0 and 1, however, higher momentum values speed up low learning and prevents from being trapped in local minimum. At the same time, large values of momentum will cause large error oscillations (NeuralWare 1996; Baughman and Liu 1995). Epoch is the number of training examples, which is introduced to network and weight updating is based on accumulated weight updating values. This method of updating weights increases the convergence speed and is known as cumulative delta rule learning. However, using

cumulative delta-rule learning for updating weights will require more calculation and if the epoch is too large the advantage of using overall error function can be lost. Therefore depending on problem, this value should be optimized. The performance of an ANN model is influenced greatly by the quantity and quality of data in training set (Linko and Zhu 1992). The training data should have sufficient information to describe relation between input and output variables. A proper format of variables could increase the learning ability of ANNs by detecting the relation between input and output variables (NeuralWare 1996). This stage of ANN models development is thus regarded as data preprocessing which could be performed in different ways to improve the model efficiency (Lacroix et al. 1997).

Keeping the above constraints in mind, to select required number of examples in training set, a learning curve was developed. The original data (1050 data) were sorted from the lowest to highest value. To have six equal groups of data, every seventh data row was selected and removed from the original set. These formed the first (Group A) data set of 175 data points. The same procedure was repeated with the remaining data until six homogenous groups (A to F) of data each with 175 data points were obtained from the original data. Each of the group thus covered the entire range of data in original set. Different combinations of these groups were used to achieve different sizes of training and testing data sets. These arrangements are shown in Table 1. The data sets that were not used for training were used for testing data during development of model. The developed models were tested also with all the available data from the original data set to evaluate the consistency of performance. This procedure was followed for both models (A and B).

Various network architectures and network learning parameters (momentum and epoch size) were examined as summarized in Table 2. To avoid over-training of models, the original data are separated into two groups as training and testing data set. Testing data were applied to cross validate the model during training stage. For this purpose, the NeuralWare software provides an option called "save best". Function of this option is to stop the training stage after a certain number of cycles, testing with testing data and saving the results of the network in a file. Each time, the result of most recent and better network is replaced with the last saved network. This procedure is continued until a pre-selected error of network is reached or after number of iterations without any improvement in learning of network. Finally, the "save best" network is retained and the model is ready for verification.

TABLE 1. COMBINATIONS OF TRAINING AND TESTING DATA FOR NETWORK OPTIMIZATION

Group (s) in training set	Group(s) in training set	Number of data pairs in training set	Number of data pairs in training set
A	B,C,D,E,F	175	875
A,F	B,C,D,E	350	700
A,C,F	B,D,E	525	525
A,B,C,F	D,E	700	300
A,B,C,D,F	E	875	175

TABLE 2. RANGE OF NETWORK ARCHITECTURE AND LEARNING PARAMETERS USED IN THE STUDY

Numbers of PES			
1 hidden layer	2 hidden layers	Momemtum	Epoch
2	2 & 2	0.2	4
5	2 & 5	0.3	8
10	5 & 5	0.4	16
15	10 & 5	0.6	20
-	-	0.8	32

* Bold numbers with underscore are default values provided in software

Stumbo method : The number of data pairs available for this model was 396 (44 f_h/U vs. g combinations for 9 j_{cc} values) and covered a large range of f_h/U and g as compared to Ball table. Input variables in developing ANN model for Stumbo method were f_h/U and j_{cc} for predicting g value or alternatively g and j_{cc} to predict f_h/U. The j_{cc} variability was considered as the second input. As in Ball models, notations of Model A and Model B were used for prediction of *log g* and f_h/U values, respectively. A part of original data was used for testing. The structure of ANN model and learning parameters were selected as defined for Ball model.

Validating the ANN models

After developing ANN models for Ball and Stumbo methods, a new set of data covering a specified range of processing conditions as shown in Table 3 were applied. A Lotus based spreadsheet program for process calculations by formula methods, developed by Ramaswamy (1991), was applied to calculate the corresponding process time or process lethality. The calculated g (or f_h/U) from the processing conditions and process time/process lethality were used to recall the ANN models and obtain the corresponding ANN value. After, these recalled ANN values were applied to calculate the ANN based process time or process lethality, the accuracy of ANN predicted values were compared with the respective values from each method. The following criteria were used for evaluating ANN models performance :

$$\text{Root Mean Square (RMS) of error} = \sqrt{\frac{\Sigma (Y_0 - Y)^2}{n}}$$

$$\text{Mean Absolute Error (MAE)} = \text{Mean of } |Y_0 - Y|$$

$$\text{Mean Relative Error (MRE, \%)} = \text{Mean of } \frac{|Y_0 - Y|}{Y_0} * 100$$

where :

Y_0 = value

Y = ANN predicted value

n = number of records

For validating ANN models of Stumbo method, the variability of j_{cc} was also considered between the processing conditions. Table 3 shows the range of conditions used to calculate Stumbo process time and process lethality.

TABLE 3. RANGE OF PARAMETERS FOR VALIDATING ANN-BASED BALL AND STUMBO MODELS

Parameters	Ball	Stumbo
RT (°C)	115-125	110-130
IT (°C)	65	70-90
f_h (min)	10-20	23-185
j_{ch}	1.2-2.0	2.04
j_{cc}	1.41	1.7-2.00
Process lethality (min)	5-64	5-15
Process time (min	13.7-147	25-400

Results and Discussion

ANN-based Ball Model

Model development and optimization : It has been recognized that the network predictability and performance is dependent on training data set, structure of the network and some relevant parameters during training. Training data set should ideally cover the desired range of problem and consist of enough records to let the network to learn the features. ANN models learn trend from the data in training data set. This capacity is based on the number of processing elements (PE) or more specifically number of connections. If the number of PEs are more than what is needed with respect to training of the model, the network may lose the generalization ability and will begin to memorize the data which is mostly undesirable (NerualWare 1996). A well-trained network is optimized between generalization ability and learning the trends in training data set. To prevent the memorizing problem, a separate data set from training data should normally be selected randomly and this data set will be applied during training stage. During training, after certain number of cycles, the training is stopped and the testing data is used to calculate the error. After the network has converged to or reached a minimum global error the training can be stopped.

For developing the ANN based Ball model, the first objective was to choose the correct size of training set, which ensures the learning and generalization ability of network simultaneously. Fig. 1 and 2 illustrate the effect of number of examples in training data set based on recalling training data set (as a measure of network ability to learn the data), as well as testing the network with testing data which were not used in training data set (as a measure of generalization ability of network). Also, each network model was tested with the entire original data set and the combined results were shown in these graphs. For both models, the errors associated with training and testing data sets were very close for each training set size, demonstrating the potential ability of network for generalization. The results also confirm that the generalization ability of network was not affected by training data set. However, the size of the training set had a significant impact on the prediction ability of network. At the lowest level tried, the errors were quite-high. For the ANN based Ball-method, a training data set of size containing as many as 175 data points could be accommodated because of the availability over 1000 data points in the original set. And even at this size, the associated errors were high and converged to lower

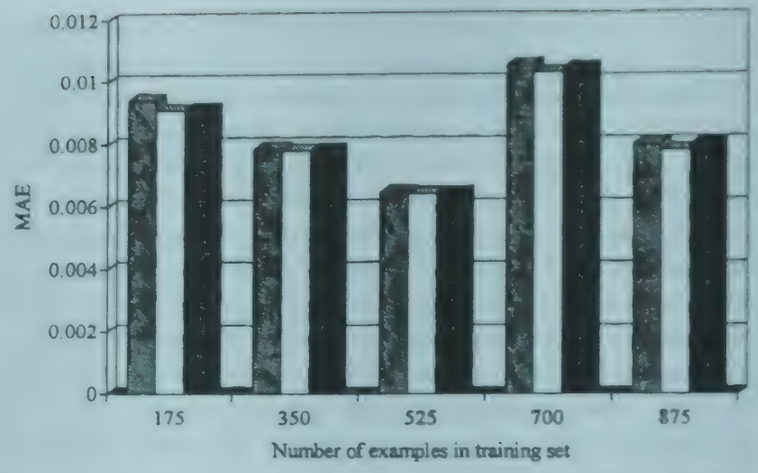


Fig. 1. Learning curve for ANN model A (prediction *log g*)

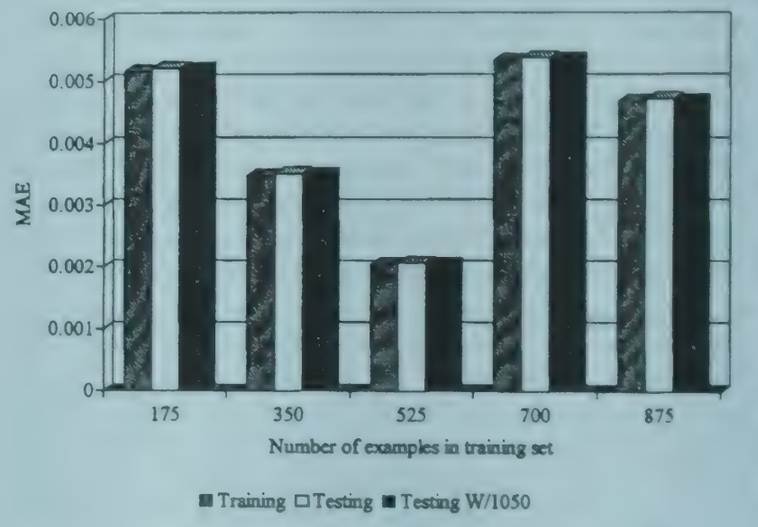


Fig. 2. Learning curve for ANN model B (prediction f_h/U)

values only after the size was increased. The network had minimum errors with a size of 525 data points which was selected for both models (A and B), the remaining being used exclusively for testing.

The error parameters for selecting the required number of hidden layers and PEs in each hidden layer are shown in Table 4. Changing the number of PEs in networks, with one hidden layer, generally resulted only in a small improvement in the performance. However, the addition of a second layer,

TABLE 4. EFFECT OF PEs AND HIDDEN LAYER(S) ON THE PERFORMANCE OF ANN BASED BALL MODELS

Number of hidden layers	Number of PEs in layers	Model A (predicting log g) RMS error	Model A (predicting log g) MAE	Model B (predicting log g) RMS error	Model B (predicting log g) MAE
1 hidden layers	2	0.068	0.037	3.584	1.041
	5	0.067	0.038	5.792	1.709
	10	0.067	0.039	2.418	0.715
	15	0.076	0.051	2.722	0.798
2 hidden layers	2 & 2	0.043	0.024	6.332	1.881
	2 & 5	0.042	0.023	1.903	0.589
	5 & 5	0.057	0.032	1.093	0.361
	10 & 5	0.073	0.051	3.106	0.903

markedly improved the prediction ability, which was more significant for Model B than for Model A. Increasing the number of hidden layers to 3 did not result in any advantage over the model with 2 hidden layers, but increased the computation time. Hence, Model A was selected with 2 hidden layers and 2 PEs in each layer, and a 2-hidden layer network with 5 processing elements in each layer was assigned for Model B. It has been generally recognized that assigning the appropriate number of PEs and hidden layer(s) is mostly a trial and error method, however, two hidden layers for most of problems is sufficient (NeuralWare 1996).

Several other parameters have role in a successful training and increasing the performance of the network: momentum and epoch size, and learning rule. The epoch size was systematically varied between the limits and its effect on the RMS was evaluated (Table 5). Epoch size did not affect prediction ability of Model A; however, it affected prediction ability of ANN model B. After selecting the correct epoch size, this parameter was fixed and the variability of momentum was considered. Table 6 shows the impact of momentum on learning of network. Increasing this parameter decreased the error parameters, but increasing it beyond some values increased the error.

Based on this initial exercise, the optimal configuration of the network for the two ANN based Ball models were determined and are shown in Table 7. The prediction performance of the ANN models with all learning parameters selected as detailed in Table 7 are illustrated in Fig. 3 as plots of ANN predicted values vs. Ball table values. The predicted values were very close to the Ball-table values and were evenly distributed throughout the entire range. Calculated error parameters and R^2 are given in Table 8, which showed that ANN models were able to accurately predict Ball table parameter.

TABLE 5. EFFECT OF EPOCH SIZE ON PREDICTION ABILITY: ANN BASED BALL MODELS

Epoch size	Model A (predicting log g)		Model B (predicting f_h/U)	
	RMS	MAE	RMS	MAE
4	0.020	0.015	0.712	0.811
8	0.021	0.016	0.542	0.836
16	0.021	0.016	1.093	0.936
20	0.021	0.016	1.481	1.031
32	0.022	0.017	2.505	1.448

TABLE 6. EFFECT OF MOMENTUM ON PREDICTION ABILITY OF ANN BASED BALL MODELS

Momentum value	Model A (predicting log g)		Model B (predicting f_h/U)	
	RMS	MAE	RMS	MAE
0.2	0.047	0.024	1.756	1.112
0.3	0.039	0.018	1.426	1.010
0.4	0.043	0.024	1.093	0.936
0.6	0.045	0.028	1.610	1.057
0.8	0.080	0.050	1.721	1.071

TABLE 7. OPTIMAL LEVELS OF ARCHITECTURAL PARAMETERS FOR ANN BASED BALL AND STUMBO MODELS

Parameter	ANN Model A Ball	ANN Model B Ball	ANN Model A Stumbo	ANN Model B Stumbo
Number of hidden layers	2	2	2	2
Number of PEs in hidden layers	2 & 2	5 & 5	2 & 2	2 & 2
Epoch size	4	8	4	8
Momentum	0.3	0.4	0.4	0.2

TABLE 8. ERROR PARAMETERS FOR ANN BASED BALL MODELS

Error parameters	ANN Ball Model A *log g* Process time		ANN Ball Model B f_h/U Process lethality	
RMS	0.04	0.607	2.48	0.165
MAE	0.02	0.458	0.66	0.084
MRE	4.98	1.025	1.14	1.321
R^2	0.99	0.99	0.99	0.99
Error parameters	ANN Ball Model A *log g* Process time		ANN Ball Model B f_h/U Process lethality	
RMS	0.08	6.43	3.25	0.33
MAE	0.06	5.06	1.35	0.24
MRE	6.13	3.04	2.78	3.03
R^2	0.99	0.99	0.99	0.99

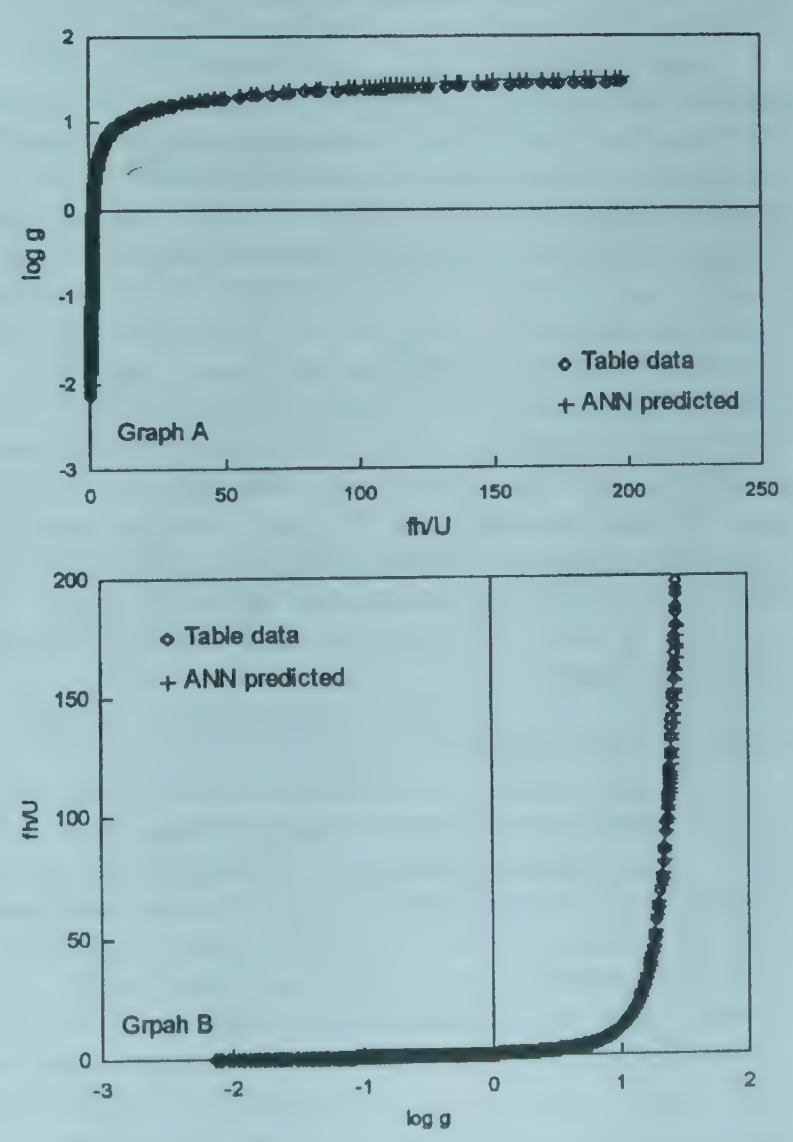


Fig. 3. Comparison of ANN predicted values and Ball table parameters respect to input variable

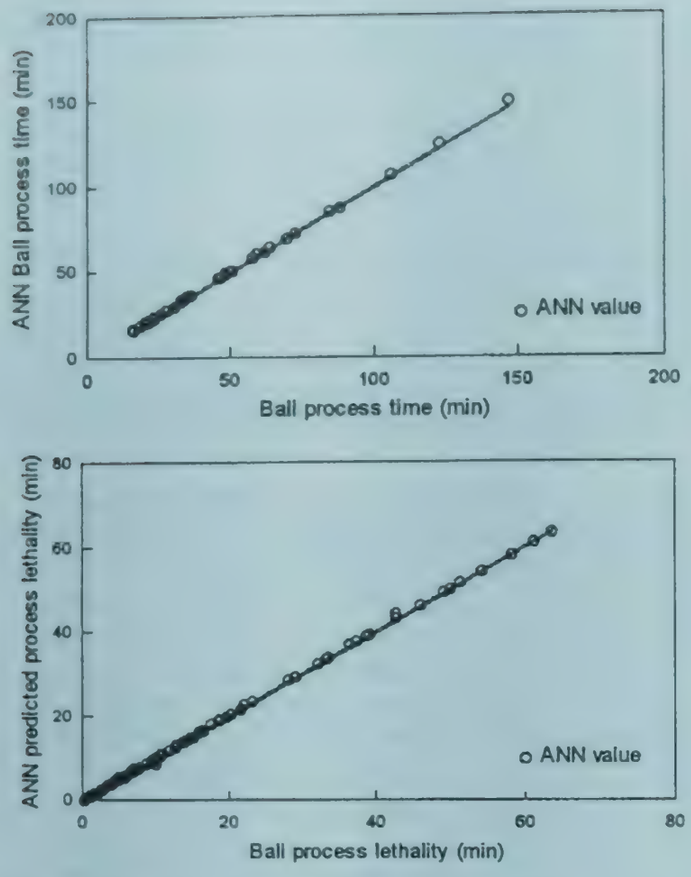

ANN Ball process time (min)
Ball process time (min)
o ANN value
ANN predicted process lethality (min)
Ball process lethality (min)
o ANN value

Fig. 4. Validating the ANN models of Ball method

Model verification : Fig. 4 illustrates the results of validation of the developed models with a new set of data which involved a wide range of operating parameters normally encountered in commercial thermal processing operations (Table 3). The prediction error parameters are also summarized in Table 8. For both models (process time prediction, Model A and process lethality prediction, Model B) the R^2 was close to unity, which showed excellent correlation between ANN model and Ball method. The associated mean relative errors for both process time and process lethality prediction were 1.0 and 1.3 %, respectively. The mean relative error is more meaningful with respect to process lethality, while for process time, the mean absolute error (0.5 min) which indicates the error in user units (min) is more easily reconcilable. Over the range of process time encountered (up to 150 min), this represents a mean range error of about 0.3 % which was considered small.

ANN-based Stumbo Model

The various pre-processing constraints were also evaluated with respect to Stumbo model although some could not be accommodated because of the smaller size of the available data. For example, since only 44 data pairs were available at each j_{cc} value, the size optimization could not be done. The required number of processing elements and the number hidden layers were optimized based on the RMS of errors and MAE. Since the quality of data between these two tables (Ball and Stumbo) were similar, optimal conditions with respect to momentum, transfer function, and learning rule were expected to be some what similar to those achieved in the ANN based Ball model. Again, 2-hidden-layer network performed considerably better than 1-hidden-layer networks. The optimal conditions for number of PEs were 2 PEs in each layer, while for one of the Ball models, the best model had 5 PEs in each hidden layer. The appropriate architecture of networks was also used to select the proper values for epoch and momentum, and these were also slightly different. The differences in the architectural configurations were considered to be the result of smaller size of data set available for Stumbo model. The optimal conditions are summarized in Table 7.

The performance of the ANN based Stumbo models as a plot of ANN predicted values vs. desired output values are shown in Fig. 5. The computed errors and the associated R^2 values are included in Table 8. The figure demonstrates an excellent agreement between predicted and expected values with a high R^2 values. The mean errors were, however, some what higher than those observed with ANN based Ball models. For Model A, for example, the MRE was 6.1 % for Stumbo model as compared to 5 % for Ball model for log g prediction and 2.8 % and 1.1 %, respectively for f_h/U predictions. The differences were considered to be primarily the result of differences in the size of available data over a wider range of f_h/U and the addition of j_{cc} as a second input. Accommodating

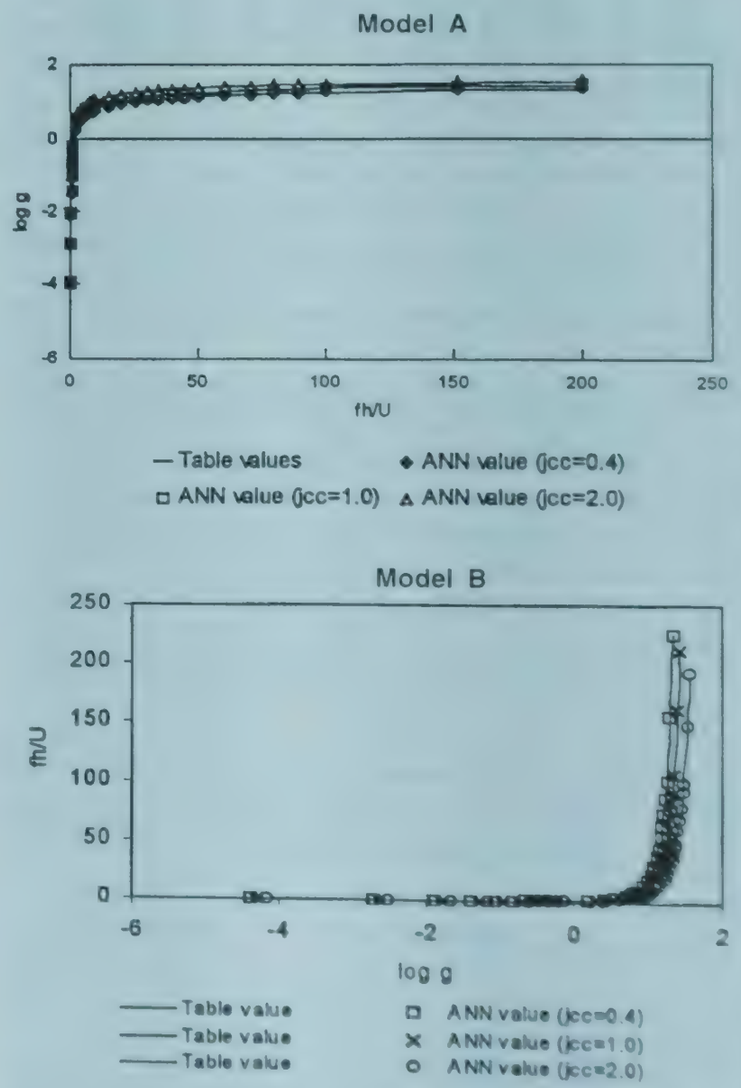
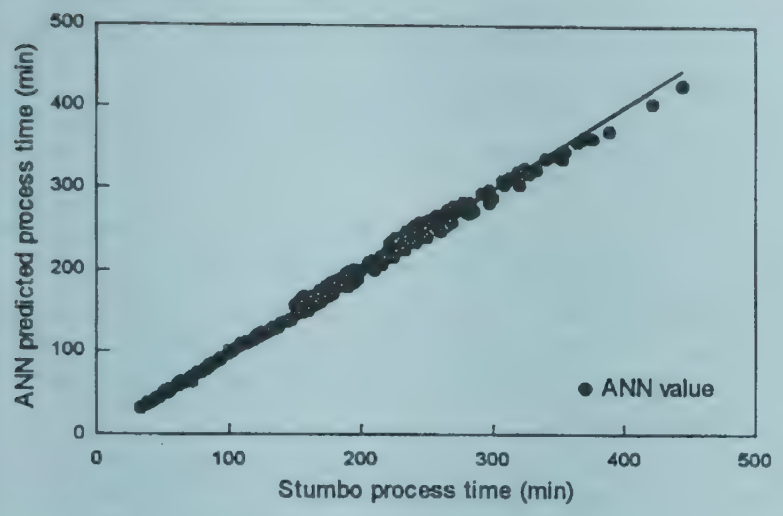


Fig. 5. Comparison of ANN predicted values and Stumbo table parameters respect to input variable



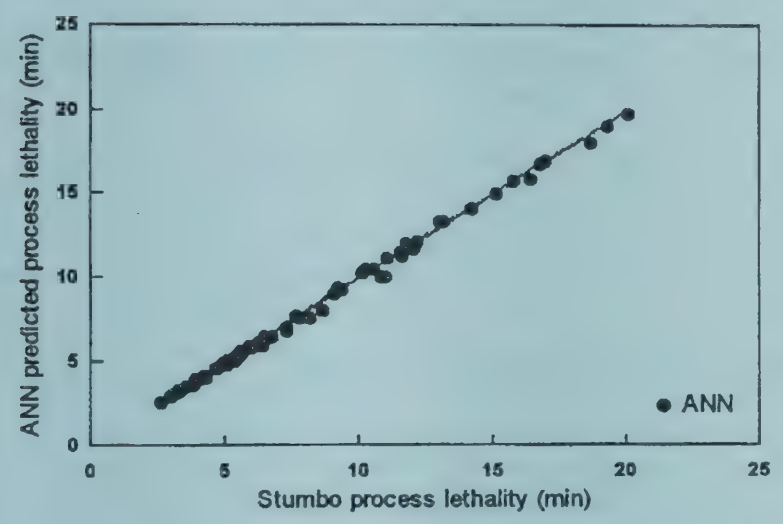


Fig. 6. Validating the ANN models of Stumbo's method

these changes probably requires a larger training set, but the number of data in Stumbo tables were far less than Ball table. It was shown earlier with ANN-based Ball model that the performance errors were quite high even with the availability of 175 data points. It may thus be logical to assume a higher performance error with Stumbo models.

The results for validating ANN models in the form of predicted vs. expected process time and process lethality is shown in Fig. 6. With respect to process lethality and process lethality predictions, the associated errors (MRE) for ANN based Stumbo models were again 3 % while they were about 1 % with ANN-based Ball models. The associated R^2 were again very high and the quality of predictions was excellent. The slightly higher errors with predictions by the ANN based Stumbo models were again ascribed to non-availability of adequate number of data sets to properly train and develop the ANN models. The associated errors were however considered low enough to demonstrate the utility of the ANN concept for simulating Ball and Stumbo process calculation techniques.

Conclusions

The feasibility of ANN model for process calculations was evaluated in this study based on their ability to simulate Ball and Stumbo methods. The ANN models were able to correlate the parameters of Ball and Stumbo tables with good accuracy (mean relative errors of 1-3 %). It was found essential to optimize the network configuration with an appropriate size of training data set, and several learning parameters. The developed ANN models were validated with a new set of data for process time and process lethality calculations covering a wide range of commercial processing conditions. ANN models predicted the process time and process lethality with mean relative error of 1 % for Ball models and 3 % for Stumbo models. The slightly higher errors associated with for ANN based Stumbo models were considered to be due to the wider range of parameters and smaller size of available training data set as compared to Ball model. However, the associated low errors and high R^2 value with the ANN based models in simulating Ball and Stumbo data demonstrate a good potential for the development of ANN models for process calculations.

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RESEARCH PAPER

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Characterization of Starch Isolated from Potato Tubers (*Solanum tuberosum* L.)

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Starch was purified from five Indian potato genotypes and a few important physico-chemical properties were determined. Starch yield was found to vary from 9 to 12.6 % on fresh weight basis. Scanning electron microscopy (SEM) studies of 'Kufri Jyoti' variety showed that potato starch granules were relatively large and oval to elliptical in shape. The mean particle size of potato starch granules varied from 40 to 60 μm among different cultivars. The total amylose content in potato starch ranged between 17.2 and 23.7 %. Potato starch contained high phosphorus content of 0.09 to 0.10 %. The swelling volume of 1 % potato starch paste ranged from 20 ml to 40 ml/g starch. Viscosity of potato starch paste was much higher compared to cereal and other tuber crop starches. X-ray diffraction studies of potato starch extracted from 'Kufri Jyoti' showed typical B-type pattern with a maximum peak at 17.1°2θ. The other significant peaks were observed at 5.7°2θ, 22.°2θ and 24°2θ.

Keywords : Potato, Starch, Viscosity, Swelling volume, Amylose, X-ray diffraction pattern.

Starch is a major component of potato tubers and can comprise between 65 and 80 % of the tuber dry weight depending on the cultivar (Phadnis and Jadhav 1991). The highest annual potato starch production is in The Netherlands, while French, Germany, Poland and Russia are important producers of starch (Bergthaller et al. 1999). About 3 % of world crop of potatoes is used for production of starch. Potato starch is used for many different purposes (Kempf 1986). The main reason for using potato starch is the rheological characteristics of this particular type of starch, which differ significantly from those of other plant sources. These rheological properties of starch solutions depend on the physical and chemical characteristics of starch such as granule size, amylose content, molecular size, phosphorus content and degree of branching. Potato starch is preferred to other starches in many food, adhesive and oil-field applications as well as in paper making, because it gives high consistency on pasting and excels in film-forming and binding characteristics. These properties are also exhibited by its derivatives (Mitch 1984).

In India, potato production has considerably increased in recent years. One of the major reasons for the above increase in production is the opening up and expansion of markets for processed potatoes, as a result the changing life styles and food habits including development of fast food sector and emergence of varied snack items. The potential for processed potato is so great, that several multinational and local companies have already established processing plants in some Asian countries. There is also an interest in producing starch from the large amounts of trim-waste and reject-potatoes from the above processing plants. Keeping in view of the tremendous increase in potato production during the last two decades, technique for extraction of starch from potato was standardized for higher recovery. Various physicochemical properties of potato starch extracted from five Indian genotypes were studied and these are useful for various applications of starch such as in pharmaceutical and food industries.

Materials and Methods

Starch extraction : Starch was extracted from Indian potato cultivars viz., 'Kufri Chandramukhi', 'Kufri Jyoti', 'Kufri Lalima', 'Kufri Sindhuri' along with exotic cultivar 'Frito Lay 1533' which were grown at Central Potato Research Institute Campus, Modipuram. The tubers were washed to remove adhering soil, followed by peeling to remove the thin outer skin. The washed tubers were sliced and 1 kg of the material was crushed for 3-4 min in a mixer at room temperature using one litre of distilled water. The material was then passed through a fine muslin to separate cell debris and the translucent suspension. To increase the starch recovery, the residue was resuspended in water and allowed to stand for 24 h. It was again crushed and sieved and the supernatant containing starch was separated. The starch was allowed to settle and the supernatant was decanted. The sedimented starch was washed 3 to 4 times with distilled water followed by sieving through muslin cloth until the wash water remained clear and free of suspended impurities. The pure starch extracted was dried in air at room temperature to a moisture level of 13-15 %. The dried starch was ground to a fine powder. The starch was accurately weighed and stored in polythene bags pending further studies.

Scanning electron microscopy : Scanning electron microscopy studies of potato starch samples sputtered with 50 nm gold/palladium (60/40) were done using Jeol scanning electron microscope.

Granule size analysis : Starch granules were examined with an OPTIPHOT-2 microscope (Nikon Corporation, Tokyo, Japan). Granule size was measured at 20 x and 40 x magnification using an ocular micrometer. Iodine solution (0.1 %) was used for staining starch granules (Mac Masters 1964).

X-ray crystallography : Potato starch samples were scanned using a Phillips PW 1710 diffractometer (England) from 5° to 60° (2 theta) with a step width of 0.05 nm. The kα radiation from a copper target was used adopting the following conditions: generator current 20 mA, divergence slit 1°, receiving slit 0.01 mm, step size/time (2θ)/s.

Determination of physico-chemical properties of potato starch : The amylose content was determined by the earlier

reported colorimetric method of Sowbhagya and Bhattacharaya (1971). Amylose and amylopectin from potato starch (E. Merck, Germany) were used as standards for calibration. The swelling volume was determined using the procedure described by Schoch (1964). Phosphorus content in the starch was determined by the method of Smith and Caruso (1964). The clarity of starch suspensions was compared from the absorbance values of the 2 % starch solutions and that of distilled water, as control, at 500 nm using UV-spectrophotometer. Viscosity of 4 % (w/v) potato starch suspension prepared in distilled water was measured using Brookfield Viscometer Model DV-II + (Brookfield) Engineering Laboratories, USA). All the values given in Tables 1, 2 and 3 represent mean average values for three replications analyzed for each parameter. Data have been statistically analysed and CD values are given at the end of the tables.

TABLE 1. PROPERTIES OF POTATO STARCH EXTRACTED FROM INDIAN CULTIVARS

Cultivar	Dry matter, %	Starch yield*, %	Average granule size, µm	Amylose content, %	Moisture content, %
'K.CM'	21.4	11.4	59.6	23.7	15.7
'K. Jyoti'	18.4	9.0	52.5	17.2	12.7
'K. Sindhuri'	20.4	10.1	45.0	19.2	13.2
'K. Lalima'	20.2	11.4	45.0	18.6	15.3
'FL 1533'	23.0	12.6	40.0	19.1	12.9
Corn starch	-	-	10.0	29.7	13.0
CD at 5 %	1.10	0.73	3.26	0.69	0.91

*On fresh weight basis

TABLE 2. SWELLING VOLUME ((ml) OF POTATO STARCH AT VARYING STARCH CONCENTRATIONS

	Starch, %						
Cultivar	0.5	1.0	1.5	2.0	2.5	3.0	4.0
'K.Chandramukhi'	20	30	38	48	56	64	67
'K. Jyoti'	22	30	34	40	55	51	66
'K. Sindhuri'	15	40	45	50	56	62	60
'K. Lalima'	18	25	35	42	55	60	60
'FL 1533'	20	34	50	50	50	60	58
Corn starch	8	10	15	26	35	40	43
CD at 5 %	3.51	3.19	4.42	3.27	3.38	4.02	4.51

*Mean of three replications

TABLE 3. VISCOSITY, CLARITY AND PHOSPHORUS CONTENT OF POTATO STARCH EXTRACTED FROM DIFFERENT INDIAN CULTIVARS

Cultivar	Viscosity (4%) cP	Clarity (2%) absorbance*	Phosphorus content ppm
'K.Chandramukhi'	386.0	1.279	0.10
'K. Jyoti'	651.4	1.643	0.10
'K. Sindhuri'	350.2	1.550	0.10
'K. Lalima'	354.8	1.309	0.09
Frito Lay 1533'	516.0	1.531	0.09
Corn starch	64.0	2.252	0.03
CD at 5 %	45.89		

*Absorbance at 500 nm

Results and Discussion

Morphological characteristics : Starch granules viewed under scanning electron microscope (Plate 1) showed that potato starch is composed of large elliptical granules of varied size ranging between 10 and 80 µm. The average granule size among cultivars ranged between 40 and 60 µm with the highest value recorded for cultivar 'K Chandramukhi' and the lowest for 'Frito lay 1533' from 40 to 59.6 µm (Table 1). Although the granules surfaces appeared quite smooth under lower magnification, a few granules indicated some fissures under high magnification. These values are in the same range as reported earlier (Swinkels 1985) and were much large compared to corn starch granules which showed granule size between 3 and 20 µm, as observed under light microscope. The potato starch granule resembled an oyster shell in appearance, due to apparent striations on the surface as observed under light microscope. There was hilum in the narrower part of the granule, which was surrounded by the concentric rings.

The X-ray diffraction pattern of potato starch (Fig. 1) showed maximum peak at around 17.1° (2θ). The other significant peaks were at 5.7°, 22.2° and 24°. Gebre-Mariam et al (1996) also reported 'B' type X-ray diffraction pattern for

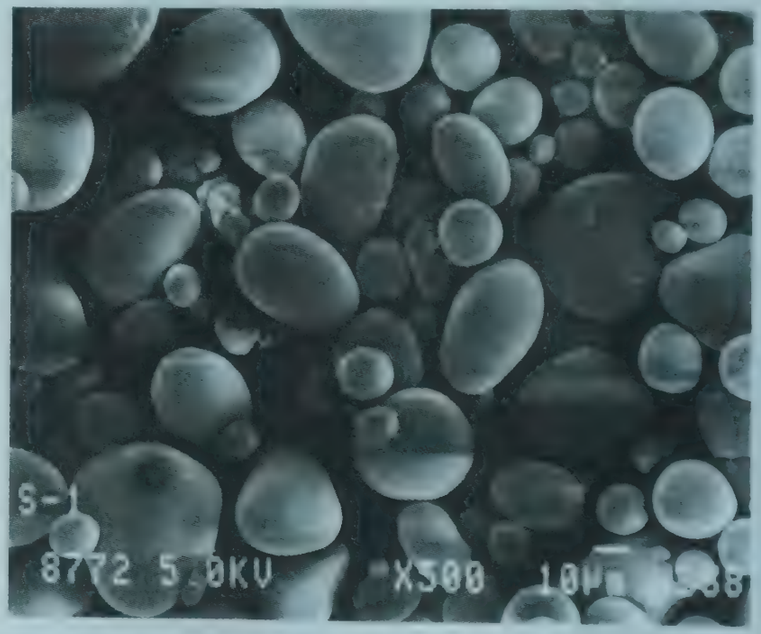

Plate 1. Scanning electron micrographs of potato starch granules isolated from 'Kufri Jyoti' under 500 x magnification

Fig. 1. X-ray difraction pattern of 'Kufri Jyoti' starch

potato and enset starch with a major peak at 17.2°. Yu et al (1999) made X-ray diffraction studies for potato and corn starches and reported "A" and "B" type patterns for corn and potato respectively. B-type starches usually have larger chain lengths for the branched component than the starches of the A-polymorph as generally observed in the case of cereal starches. These X-ray diffraction studies suggest more crystalline nature of potato starch.

Physico-chemical properties of potato starch : The yield of potato starch varied from 9 to 12.6 % on a fresh weight basis (Table 1). The highest being for 'Frito Lay 1533', followed by Indian varieties 'Kufri Chandramukhi', 'Kufri Lalima' 'Kufri Sindhuri' and 'Kufri Jyoti' respectively. The starch yield was found directly correlated to the dry matter content of the tubers. The linear component of starch, viz., amylose, imparts definite characteristics to starch and hence is an important criteria in starch quality. Amylose content ranged between 17.2 and 23.7 % among different cultivars. Although a small variation in amylose content is observed among different varieties in potato, it does not suggest any correlation between granule size and amylose content. Ganga and Corke (1999) observed relatively wide variation in the amylose content with values ranging from 20 to 35.1 % among different genotypes grown in The Philippines. Phadnis and Jadhav (1991) also observed that in general, the amylose content in starch ranges from 18.5 to 32.0 % in different potato genotypes.

The swelling volume of the starch of different cultivars determined at 95°C for various concentrations as presented in Table 2 showed wide variations among different cultivars ranging between 25 and 40 ml g^{-1} at 1 % starch concentration. The values increased steadily with increase in concentration until it tapered off above 3 % concentration except in 'Kufri Chandramukhi' and 'Kufri Jyoti'. At higher concentrations, there was not enough water for the granules to imbibe and swell. The largest swelling volume was obtained for cultivar 'Kufri Jyoti' at 0.5 % concentration. This is in line with the highest viscosity obtained for 'Kufri Jyoti' starches. Lower swelling volumes were observed for starches of 'Kufri Lalima' and 'Kufri Sindhuri' at 0.5 % concentration, which also have lower viscosity. These starches may be possessing stronger associative forces. Potato is known to have higher swelling volume as well as high swelling power due to presence of negatively charged phosphate groups which assist in swelling of the potato starch granules (Swinkels 1985). The swelling power of maize and wheat starches is low compared to potato starch. Phosphate ester linkages in starches have been known to modify starch properties (Osman 1967). Phosphorus content in potato starch was found to vary between 0.09 and 0.10 % which was much higher compared to other tuber crop starches such as cassava and taro. Potato starch paste (4 % w/v) showed high viscosity between 350.2 and 651.4 cP among different cultivars, and the above values are much higher than cereal and other tuber crop starches. High gel strength and peak viscosity of potato starch are due to phosphate cross linkages which are more difficult to break (Swinkels 1985). Potato starch paste showed high clarity compared to corn starch which is another important feature suitable for various applications (Table 3).

Conclusions

Present studies gave an insight to some of the important properties of potato starch (*Solanum tuberosum* L) that makes it superior to cereal starches. Due to its high viscosity and high swelling power potato starch can be exploited for use in textile, food, paper and pharmaceutical industries (Joshi and Kulkarni 1993). For low cost production of potato starch, surplus and damaged potatoes, available during gluts, could be used. Increased production of starch from potatoes has a lot of scope for the industry with respect to value-added starch based products, indirectly generating higher employment and saving country's foreign exchange.

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RESEARCH PAPER

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Purification of an Antigenic Glycopeptide from Buffalo Colostrum

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A sialoglycopeptide was fractionated and purified on Sephadex G-25 and QAE-Sephadex A-25. Its homogeneity was confirmed by reverse phase-HPLC and electrophoresis. It consisted of NeuNAc, Fuc, Gal, Man, GlcNAc in the ratio 1:1:2:1:1 and Asp, Glu, Ser, Thr, Pro as major amino acids.Lysine was found to be the N-terminal amino acid residue. Antibodies raised to the glycopeptide were immunogenic and were similar to blood group-A substance as determined by immunodouble diffusion and hemagglutination techniques.

Keywords : Buffalo colostrum, Glycopeptide, Antigenic, Purification, Chemical characterization.

Colostrum (early milk) contains not only all the essential nutrients, but also glycoproteins, glycolipids, glycopeptides and oligosaccharides often resembling those of cell surface glycoconjugates (Falconer 1971; Kobata et al. 1978; Nieuwenhof et al., 1999). The functional importance of these biomolecules having bacteriostatic, bactericidal and antiviral activities is widely recognised (Blanc 1981; Chandra 1978; Parkinen and Finne 1985; Aparna and Salimath 1994). The glycopeptides have attracted considerable attention with regard to their ability to enhance the growth of bifidobacterium (Gyorgy et al. 1974) and as blood group substances (Hoover et al. 1953; Yates et al. 1974), besides their role in growth and development of the newborn. The studies on glycopeptides are confined mainly to human colostrum (Veh et al. 1981) and no such studies have been conducted on buffalo colostrum. Therefore, the present study was undertaken on the purification and blood group activity of a glycopeptide from buffalo colostrum.

Materials and Methods

Isolation and fractionation of glycopeptides : Fresh buffalo colostrum from the first two days after delivery was collected locally and stored at -20°C. The glycopeptides were extracted using chloroform-methanol mixture (2:1, v/v) and were fractionated on Sephadex G-25 column (150 x 2.5 cm) using water as eluant. Peak II of the above fractionation was chromatographed on QAE-Sephadex A-25 column (40 x 2.5 cm) using water and ammonium acetate buffer, respectively (Aparna and Salimath 1996). The fractions so obtained were desalted on Biogel P-2 column (40 x 2.5 cm) and lyophilized.

Homogeneity of the glycopeptide : The homogeneity of the glycopeptide was tested by cellulose acetate membrane electrophoresis (Beckman Instruments, Switzerland) using acetate buffer (pH 5.0, 50 mM) and the electrophoregrams were stained with silver nitrate reagent prepared in ethanol instead of acetone (Trevelyan et al. 1950). Reverse phase HPLC was carried out on a C-18 column (250 x 4.6 mm) using Shimadzu HIC-6A chromatograph (Hermodson and Mahoney 1983). The mobile phase consisted of (A) 0.1 % trifluoroacetic acid (5 min) and a linear gradient of (0-100 %) acetonitrile (B) containing 0.1% trifluoroacetic acid (30 min) at a flow rate 1ml/min with the detector set at 220 nm. SDS-PAGE (12 %) of the lyophilised sample was carried out under reducing conditions using *tris*-glycine buffer (pH 8.3) and stained with Coomassie Brilliant Blue (Weber and Osbern 1969).

Chemical methods : The amino acid composition of the hydrolysed peptide (6N hydrochloric acid containing 1 % liquid phenol, 110°, 24h under vacuum) was determined as phenylthiohydantoin labelled amino acids (Bidlingmeyer et al. 1984) and were identified on a Waters PICO-TAG column (0.25 x 250 mm, Waters Assoc., USA) using HPLC system. N-terminal amino acid analysis was carried out by double coupling method using 4-dimethyl-amino-azobenzene-4'-isothiocyanate (Chang 1983). Sialic acids, amino sugars, and neutral sugars were estimated according to the methods of Aminoff (1961), Reissig et al (1955) and McKelvy and Lee (1969), respectively. Quantitations of neutral and amino sugars were done by GLC as their alditol acetates using 3 % OV-225 column (8 x 1/8 ft, Pierce Chemicals Co., USA) at 190° and 230° respectively (Sawardekar et al. 1967; Weber and Carlson 1982).

Antibody production : Female rabbit was immunized with glycopeptide (200 µg) emulsified with complete Freund's adjuvant (1 ml). The preparation was injected intradermally on the back and was repeated three times at intervals of 1 to 2 weeks in Freund's incomplete adjuvant. Bleedings were obtained at intervals of 4 to 7 days starting 2 weeks after the initial immunization. The cross reactivity of antiserum was tested by Ouchterlony immunodiffusion technique (Vaitukaitis 1981).

Hemagglutination activity : Human (type A, B, AB, O) RBC were collected from the vein in an equal volume of Alsever's solution. Washed RBCs were suspended in saline (0.9 %). Hemagglutinating activity was determined using serial dilutions of purified antibody. Each well contained RBC suspension (2 %, 20 µl) and antibody (200 µl). The mixtures were left for 60-90 min at 37°C. Agglutinated RBC formed a diffused mat on the bottom of each well which was distinct from a clear dot formed by non-agglutinated RBC (Barondes et al. 1978).

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Results and Discussion

The chloroform-methanol extract of colostrum (3.3 %) fractionated on Sephadex G-25 gave three saccharide pools eluting prior to lactose. The first fraction (0.7 %) contained glycopeptides, second fraction (1.2 %) contained both glycopeptides and oligosaccharides (Fraction II), while the third fraction contained only oligosaccharides. When the second fraction was rechromatographed on QAE Sephadex A-25, unbound fractions were eluted as three peaks with water (12 %) and bound fractions were subsequently eluted into seven fractions in 0.1 M (43 %), three in 0.25 M (33 %) and three in 0.5 M (7 %) buffer as reported earlier (Aparna and Salimath 1995).

The electrophoresis of the isolated fractions on cellulose acetate membranes revealed only fraction 'm' to be homogeneous. Subsequently, when other major fractions (a, f, i, k) were rechromatographed on Sephadex G-25 fraction 'k' was found homogeneous (data not shown) and was obtained in an average yield of 14 mg/L. Fraction 'k' (GP-1) stained both for carbohydrates and proteins, while 'm' was identified as free oligosaccharide (Aparna and Salimath 1995). On reverse phase HPLC, GP-1 eluted as a single peak and had a retention time of 26.75 min. On SDS-PAGE, it moved as a single band and had a relative molecular weight (Mr) of 15.1 kD (Fig. 1).

The amino acid composition of GP-1 is given in Table 1. The content of hydrophilic amino acids was more compared to hydrophobic amino acids. In addition, absence of cysteine was an important feature. Lysine was identified as the N-terminal amino acid residue. The sugar analysis revealed the presence of NeuNAc, Fuc, Gal, Man and GlcNAc in the ratio 1:1:2:1: Some of these features would make it different from other purified glycopeptides of buffalo, and human colostrum (Aparna and Salimath 1996; Hirano et al. 1968). Sialoglycopeptide studied by us from buffalo colostrum (Aparna and Salimath 1996) contained aspartic acid and glutamic acid mainly and glycine was the N-terminal amino acid. Fucose,

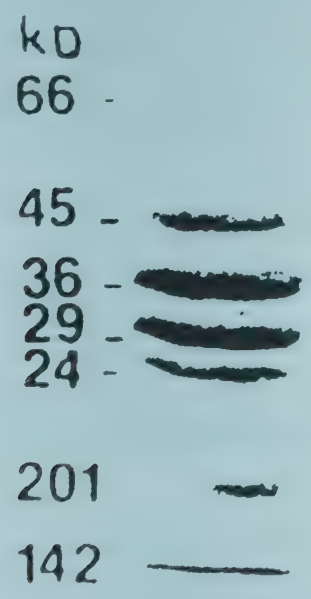

Fig. 1. SDS-PAGE of GP-1 run under reducing conditions on 12 % slab gel along with low molecular weight standards. Gels were stained with Coomassie Brilliant Blue

TABLE 1. AMINO ACID COMPOSITION OF GP-1*

	Mole, %
Asn + Asp	13.6
Gln + Glu	11.4
Serine	13.4
Glycine	3.7
Histidine	1.6
Arginine	1.3
Threonine	14.5
Alanine	8.7
Proline	10.9
Tyrosine	1.8
Valine	6.3
Methionine	0.9
Isoleucine	2.3
Leucine	3.7
Phenylalanine	2.3
Lysine	3.4

*Analysis of tryptophan not done

Plate 1. Ouchterlony immunodiffusion of GP-1
Wells : 1. Antiglycopeptide antiserum; 2. Pre-immune serum; 3. Fraction II, 4. GP-1; 5. Disialyl lactose

galactose, mannose, N-acetyl glucosamine and N-acetyl neuraminic acid were present in 1:2:3:4:1 ratio.

When antibodies were raised to GP-1, it was found to cross react with GP-1 as observed by the appearance of white precipitating band upon immuno double diffusion technique (Plate 1). But, it did not cross react with any of the other purified glycopeptides of buffalo colostrum (Aparna and Salimath 1996). This not only indicated the immunogenicity of GP-1 but also its specificity. It has been found that human colostrum oligosaccharides exhibit hapten activities towards blood group A glycoproteins and glycolipids (Hansson and Zopf 1985). When blood group activity of anti GP-1 was tested against human A, B, AB, O groups, it agglutinated only blood group 'A' with the agglutination unit of 40/ml. This suggested that it was similar to blood group substance. Although blood grouping has not been very well established in animals, presence of these substances in buffalo colostrum cannot be

ruled out. In fact, many of the glycopeptides isolated from human milk are shown to exhibit blood group activities (Hoover et al. 1953; Yates et al. 1984). Further studies to verify the reactivity of GP-1 with different antiserum samples will be interesting.

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RESEARCH PAPER

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Effect of Soaking, Germination, Heating and Roasting on the Chemical Composition and Nutritional Quality of Soybean and Its Utilization in Various Indian Leavened Products

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Soybeans obtained from variety "Green" were cleaned, soaked (12 h), germinated (48 and 96 h), heated (80°C for 15 min) and roasted (20 min) before converting into flour fineness. Protein and fat contents were found to increase with germination of soybeans. Heat treatment given to soaked and soaked and germinated (48 and 96 h) samples increased the contents of the nutrients, while roasting of soybeans slightly decreased the protein and fat contents. Free fatty acids, free amino acids, the total carbohydrates and starch contents decreased with different treatments. Diastase and protease activities increased with increase in germination period. However, trypsin inhibitor activity was reduced with soaking, germination and heating of soybeans. Supplementation of wheat flour with soybean flours upto 15 % was acceptable for making acceptable quality *nann* and *kultche*. The higher levels of soybean were acceptable for making *gulgulae* (upto 20 %), *bhuturu* (upto 30 %) and *babru* (up to 30 %). The heat treatment given to soaked, soaked and germinated (48 and 96 h) soybeans further improved the acceptability of the products.

Keywords : Soybean, Soaking, Germination, Heating, Roasting, Blends, Indian leavened products.

Soybean being rich in proteins and energy has a great potential to solve the problem of protein energy malnutrition in India and many other developing countries. One way of utilizing soybean as food is by fermentation (Khader 1983). Soybean is also used directly as vegetable or *dhal* and in dairy or bakery products. However, the processed foods from soybean in India are relatively low. The supplementation of cereal-based diets with soybean can play an important role in combating the protein energy malnutrition.

However, soybean being rich in nutrients, its acceptability as raw food is limited due to the presence of anti-nutritional factors such as, trypsin-inhibitor, saponins, haemagglutinins, beany flavour, bitterness and poor digestibility (Liener 1981). The nutritional quality of the raw soybean can be improved by subjecting it to various treatments before being used in preparation of food items. Among the treatments, soaking and germination reduce oligosaccharides and anti-nutritional factors, cooking and drying destroy enzymes and harmful microorganisms. The treatments also make soybean free from objectionable flavour and render it to be palatable and acceptable for human consumption.

In order to improve the nutritional quality of different Indian leavened products viz., *nann, kultche, bhuturu, gulgulae* and *babru* common in the diets of Indians particularly in Northern India and to develop methods of preparation from composite flours, the present study was undertaken to study the acceptability and nutritional quality of 'soaked', 'germinated (48 and 96 h)', 'heated (80°C for 15 min)' and 'roasted (20 min)' soybeans in various Indian leavened products.

Materials and Methods

Preparation of soybean flours : The soybeans of variety "green" samples used in the study were procured from Seed Production Unit, Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The soybean grains were soaked in potable tap water for 12 h at room temperature and grain to water ratio was 1:3 (1 part grain and 3 parts water). The soaked samples were divided into four lots. Two lots were incubated for 48 and 96 h in an incubator at 25 ± 2°C after placing in germination sheets. After requisite incubation period, one lot of each legume was given heat treatment at 80°C for 15 min and then dried in a tray drier at 35-40°C till constant weight. One lot of soybean was roasted for 20 min. The soybean samples prepared from soaked, germinated (48 and 96 h), heated (80°C for 15 min) and roasted were converted into flour fineness and stored in air tight containers for further analysis and product development studies.

Chemical analysis : All the flour samples of wheat and soybean were analysed for protein content (N x 6.25, Micro Kjeldhal method of AOAC 1990), fat (AOAC 1990) carbohydrates and trypsin inhibitor activity (NIN 1983), free fatty acids and sugars (AACC 1976), free amino acids (Lie 1973). The diastase activity was determined using Bush and Sandstedf method of AACC (1976). The protease activity was determined using Arye and Anderson method (AACC 1976) with modification in that instead of determining soluble nitrogen, protein was determined by the method of Lowry et al (1951). The lipase activity was estimated as percent oleic acid on fat basis using AACC (1976) quick method for free fatty acids.

Product development and evaluation : The Indian leavened breads viz : *naan, kultche, bhuturu, gulgulae* and *babru* were prepared using recipes standardized in the laboratory. The ingredients and steps followed in the preparation of the products are given in Table 1. These leavened products were analysed for water absorption, dough handling, puffing and sensory characteristics. Organoleptic characteristics (colour, tearing, taste, chewiness and texture) were determined using a taste panel of 8 members. Panelists scored the products on the basis of colour (too dark, dark, moderately

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TABLE 1. INGREDIENTS USED AND STEPS FOLLOWED IN PREPARATION OF INDIAN LEAVENED PRODUCTS

Ingredients/Steps	*Naan*	*Kultche*	*Bhuturu*	*Gulgulae*	*Babru*
Ingredients					
Refined wheat flour, g	100*	100*	-	-	-
Whole wheat flour, g	-	-	100**	100**	100**
Yeast, g	2.5	3.0	-	-	10
Fermented dough, g (*Khameera*)	-	-	20	20	-
Sugar, g	0.5	-	-	40	40
Salt, g	0.5	1.5	-	-	-
Fat, g	-	5.0	-	-	-
Water	Optimum	Optimum	Optimum	Optimum	Optimum
Dry fruits, g	-	-	-	20	-
Oil	-	-	to fry	to fry	to shallow fry
Baking schedule					
Mixing	Optimum	Optimum	Optimum	Optimum	Optimum
Fermentation at 30°C	4 h	90 min	3 h	3 h	3 h
Remixing	-	25 sec	-	-	-
Recovery	-	25 min	-	-	-
Sheeting and Moulding	-	-	-	-	-
Proofing	-	45 min	-	30 min	-
Baking/Frying	-	220°C	Deep frying	Deep frying	Shallow frying
Time	3 min	15 min	-	-	-
No. of products prepared	4	2	4	8	8

* Containing0, 5, 10 and 15 % soybean flour

* Containing 0, 10, 20, 30 and 40 % soybean flour

light, light, too light), tearing (very easy, easy, moderately easy, slightly easy, tough), taste (pleasing, moderately pleasing, mildly pleasing, trace, off), chewiness (very soft, soft, semi-hard, hard, very hard) and texture (smooth, moderately smooth, mildly smooth, mildly coarse, moderately coarse) on the scale modified, while taking into consideration the scale given by Dhaliwal et al (1996).

Statistical analysis : The experiments were replicated three times. Observed data were subjected to analysis of variance (ANOVA) test (Gomez and Gomez 1984).

Results and Discussion

Protein, free amino acids, fat and free fatty acids : The protein, free amino acids, fat and free fatty acid contents as affected by soaking, germination, heating and roasting treatments are given in Table 2. The germination of soybeans had an increasing effect on protein content. Khader (1983) also reported increase in protein content after germination. Similarly, soaking of soybeans also improved the protein contents. On the other hand, heating of 'soaked' and 'soaked and germinated' grains of soybeans significantly decreased the protein content. Similarly, roasting of soybean grains also decreased the protein content. Free amino acid contents of soybean also significantly decreased with soaking, germination, heating and roasting treatments. The fat content increased with soaking and germination (48 h) of soybeans. However, a decrease in fat content was observed after 96 h of germination. Similar results of decrease in fat content after prolonged germination are reported by Khader (1983) and Mostafa et al (1987). The roasting treatment also decreased the fat content. The free fatty acid contents of soybean also decreased with soaking, germination, heating and roasting treatments.

TABLE 2. PROTEIN, FREE AMINO ACIDS, FAT AND FREE FATTY ACID CONTENTS OF SOYBEAN FLOURS AS AFFECTED BY SOAKING, GERMINATION AND HEATING

Treatment(s)	Protein (N x 6.25), %	Free amino acids, % as glycine	Fat, %	Free fatty acids, % as oleic acid
Untreated	32.89	0.24	19.52	0.210
Soaked	35.40	0.22	20.78	0.195
Soaked and heated	34.91	0.20	19.91	0.180
Soaked and germinated (48 h)	39.35	0.18	20.96	0.105
Soaked and germinated (48 h) and heated	38.14	0.17	20.40	0.095
Soaked and germinated (96 h)	40.48	0.15	18.48	0.065
Soaked and germinated (96 h) and heated	38.42	0.14	17.51	0.060
Roasted	32.80	0.16	19.45	0.020
Mean	36.50	0.18	19.63	0.116
CD ($p \leq 0.05$)	0.60	0.02	0.61	0.015

Carbohydrates and sugars : Table 3 indicates the carbohydrate and sugar (reducing, non-reducing and total) contents of soybeans as affected by soaking, germination, heating and roasting treatments. The soaking, germination and heating treatments given to soybean grains decreased

TABLE 3. TOTAL CARBOHYDRATES AND SUGARS (REDUCING, NON-REDUCING AND TOTAL) OF SOYBEAN FLOURS AS AFFECTED BY SOAKING, GERMINATION AND HEATING

Treatment (s)	Total carbo-hydrates,%	Reducing sugars, % as glucose	Non-reducing sugars,% as sucrose	Total sugars, % as glucose
Untreated	21.32	2.58	0.45	3.55
Soaked	18.28	2.71	0.44	3.67
Soaked and heated	19.29	3.03	0.53	4.17
Soaked and germinated (48 h)	13.56	3.92	0.62	5.28
Soaked and germinated (48 h) and heated	15.58	3.67	0.58	4.93
Soaked and germinated (96 h)	15.20	4.54	0.60	5.84
Soaked, germinated (96 h) and heated	18.31	4.17	0.59	5.47
Roasted	20.97	2.87	0.49	3.92
Mean	17.81	3.44	0.54	4.60
CD (p≤0.05)	1.03	0.30	0.07	0.32

TABLE 4. DIASTASE, PROTEASE, LIPASE AND TRYPSIN-INHIBITOR ACTIVITIES OF SOYBEAN FLOURS AS AFFECTED BY SOAKING, GERMINATION AND HEATING

Treatment (s)	Diastase, mg maltose/ 10 g flour	Protease, mg protein hydrolysed/ 100 g flour	Lipase, % fat acidity on fat basis	Trypsin inhibitor TUI/g flour
Untreated	179.50	329.50	1.08	98.68
Soaked	210.00	346.00	0.94	96.97
Soaked and heated	179.00	316.00	0.90	70.33
Soaked and germinated (48 h)	250.50	365.50	0.50	59.10
Soaked and germinated (48 h) and heated	221.50	348.50	0.47	37.54
Soaked and germinated (96 h)	276.00	382.00	0.35	51.50
Soaked, germinated (96 h) and heated	247.50	358.50	0.34	35.26
Roasted	148.00	315.00	1.03	45.96
Mean	214.00	345.13	0.70	61.92
CD (p≤0.05)	16.38	3.82	0.09	0.62

the total carbohydrate contents. This was because of active respiration process during soaking and germination. Roasting of soybean grains decreased the carbohydrate contents. On the other hand, soaking, germination and heating increased the reducing, non-reducing and total sugars due to the activities of α and β amylase enzymes, which increased with soaking and subsequent germination.

Diastase, protease, lipase and trypsin inhibitor activities: Diastase, protease, lipase and trypsin inhibitor activities of soybean as affected by soaking, germination, heating and roasting treatments are given in Table 4. The soaking and subsequent germination had increasing effect on diastase and protease activities of soybean, but the heat treatment given to 'soaked' and 'soaked and germinated' soybeans decreased the diastase and protease activities. Srivastava et al (1988) also reported an increase in amylase activity during soaking of pigeon pea. The results on germination are in agreement with those of Pomeranz and Robbins (1971), who reported that amylolytic activities increased with germination. Trypsin inhibitor activities of soybeans decreased with soaking. The germination of soybean grains showed a decreasing trend on trypsin inhibitor activities. Similar effect of germination of soybean grains on trypsin inhibitor activity was also reported by Bau et al (1997). The roasting also had decreasing effect on trypsin inhibitor activities and results are in agreement with the findings of Ramamani et al (1996).

Product preparation and evaluation : The data pertaining to water absorption, dough handling and puffing properties of *naan, kulthce, bhuturu, gulgulae* and *babru* prepared using different blends of wheat flour and soybean flours are given in Table 5. The addition of soybean flour into wheat flour

TABLE 5. WATER ABSORPTION, DOUGH HANDLING OF BLENDS AND PUFFING OF *NAAN, KULTCHE, BHUTURU, GULGULAE* AND *BABRU* PREPARED FROM WHEAT FLOUR CONTAINING DIFFERENT PROPORTIONS OF SOYBEAN FLOURS

Products/blends	Water absorption,%	Dough handling	Puffing
Naan			
100:0	50.17	Non-sticky	-
95.:5	50.42	Non-sticky	-
90:10	51.42	Non-sticky	-
85:15	53.38	Slightly sticky	-
Kultche			
100:0	50.17	Non-sticky	-
95.:5	50.42	Non-sticky	-
90:10	51.42	Non-sticky	-
85:15	53.38	Slightly sticky	-
Bhuturu			
100:0	40.17	Non-sticky	Full
90.:10	39.44	Non-sticky	Full
80:20	39.42	Non-sticky	Full
70:30	40.30	Slightly sticky	Full
60:40	41.67	Slightly sticky	Partial
Gulgulae			
100:0	44.64	Non-sticky	Full
90:10	40.68	Non-sticky	Full
80:20	39.18	Non-sticky	Full
70:30	37.18	Slightly sticky	Full
60:40	36.68	Sticky	Partial
Babru			
100:0	208.68	-	-
90:10	209.17	-	-
80:20	211.18	-	-
70:30	216.68	-	-
60:40	219.68	-	-

TABLE 6. MEAN VALUES OF COLOUR, TEARING, TASTE, CHEWINESS, TEXTURE AND OVERALL ACCEPTABILITY OF *NAAN, KULTCHE, BHUTURU, GULGULAE* AND *BABRU* PREPARED FROM WHEAT FLOUR CONTAINING DIFFERENT PROPORTIONS OF SOYBEAN FLOURS

Blends/products	Colour (20)	Tearing (15)	Taste (25)	Chewiness (15)	Texture (25)	Overall acceptability (100)
Naan						
100:0	16.00	15.50	23.75	10.13	23.75	84.13
95.:5	14.45	8.72	21.17	11.63	21.64	77.61
90:10	11.63	10.94	17.97	11.63	18.52	70.69
85:15	8.31	11.08	13.05	11.63	16.72	61.79
CD ($P \leq 0.05$)	0.71	0.68	0.89	NS	0.87	1.65
Kultche						
100:0	19.00	10.50	22.75	10.13	24.38	86.76
95.:5	18.19	8.72	17.98	11.63	13.56	73.08
90:10	16.06	10.94	16.48	11.63	16.81	71.92
85:15	13.88	11.08	14.00	11.63	16.41	67.00
CD ($P \leq 0.05$)	0.81	NS	1.21	NS	1.50	1.89
Bhuturu						
100:0	20.00	9.00	24.38	11.63	18.75	83.06
90.:10	18.83	7.53	19.06	9.38	18.75	73.55
80:20	16.87	6.00	15.86	9.38	18.75	66.16
70:30	14.45	6.06	10.94	9.38	18.75	59.58
60:40	12.11	6.03	9.48	9.38	18.75	55.75
CD ($P \leq 0.05$)	0.79	0.04	13.84	NS	NS	1.53
Gulgulae						
100:0	13.00	11.63	24.38	9.00	21.88	82.39
90:10	12.88	9.38	19.06	7.53	24.38	70.73
80:20	10.69	9.38	15.86	6.00	18.05	59.98
70:30	9.31	9.38	10.94	6.06	15.16	50.85
60:40	8.31	9.38	9.48	6.03	13.28	46.48
CD ($P \leq 0.05$)	0.75	NS	1.34	0.04	0.93	1.30
Babru						
100:0	16.00	13.00	24.38	15.00	18.75	87.13
90:10	11.88	12.88	19.06	14.86	18.75	77.43
80:20	10.63	10.69	15.86	14.44	18.75	70.37
70:30	8.14	9.31	10.94	14.77	18.75	61.98
60:40	6.50	8.31	9.48	14.34	18.75	57.38
CD ($P \leq 0.05$)	0.56	0.75	2.34	0.34	NS	2.01

increased the water absorption except in case of *gulgulae* where water absorption to prepare dough of desirable consistency was decreased. The water absorption was higher in wheat flour containing roasted soybean flour. Indrani et al (1997) also reported that replacement of wheat flour with different levels of defatted soyflour increased the Farinograph water absorption. The dough prepared from wheat flour (100 %) were non-sticky. Up to 20 % level of substitution of soybean flour into wheat flour did not have much effect on dough handling and dough obtained was non-sticky. However, above 20 % level of substitution of soybean flour into wheat flour the dough obtained was slightly sticky. The heat treatment given to soybeans made dough handling easier. The puffing in case of *bhuturu* and *gulgulae* prepared from wheat flour (100 %) was full and wheat flour containing 20 % levels of soybean flour.

Organoleptic evaluation of Indian leavened products : The mean values for colour, tearing, taste, chewiness and texture of *naan, kultche, bhuturu, gulgulae* and *babru* prepared from wheat flour containing different proportions of soybean flours are given in Table 6. The colour, taste and texture of soybean flour fortified *naan* and *kultche* were significantly affected and mean scores decreased with increasing levels of soybean flours. The scores for colour, taste and texture of *naans* decreased with addition of soybean flour. But the heat treatment given to 'soaked to 'soaked' and 'soaked and germinated' samples improved these scroes. The overall acceptability was also higher in *naans* prepared from heat-treated soybean flour and upto 15 % level of addition of soybean flour was acceptable for making good quality *naans* and *kultche*. Addition of soybean flour in preparation of *bhuturu*, the colour, tearing and taste were decreased. However, there was no marked reduction in the scores for chewiness and texture. Heat treatment given to 'soaked and germinated' soybeans improved the colour, taste and overall acceptability of *bhuturu*. Addition of soybean flour upto 30 % level in wheat

flour was acceptable for making good quality *bhuturu.* Similarly, for the preparation of *gulgulae* the colour, taste, chewiness and texture decreased with increasing the levels of soybean flour in the formulation and formulations having heat treated and roasted soybean flours had higher acceptability. Addition of soybean flour upto 20 % level in wheat flour was acceptable for making good quality *gulgulae.* In case of *babru* the sensory scores for colour, taste and chewiness significantly decreased, whereas there was no marked reduction in the scroes for tearing and texture. Control samples had maximum overall acceptability followed by those products containing heat treated and roasted soybean flours. Blending of whole wheat flour upto 30 % level with soybean flour was acceptable for preparation of *babru.*

From the results obtained, it is concluded that the treatments viz; soaking, germination, heating and roasting improved the nutritional quality of soybeans. The heat treatment given to 'soaked' and 'soaked and germinated' soybeans was beneficial in improving the acceptability of the products prepared from the composite flours. Supplementation of refined wheat flour with soybean flours upto 15 % levels was acceptable for making *naan* and *kultche.* Higher levels of soybean were acceptable for making *bhuturu* and *babru* upto 30 % and *glulgulae* upto 20 %. Trypsin-inhibitor activity of soybean also decreased with soaking, germination, heating and roasting treatments.

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RESEARCH PAPER

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Retention of Total and β-Carotenes from Fresh Radish Leaves in Shallow-Fried, Steamed/Sauteed and Baked Products of Western India

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Three cereal/pulse-based recipes of Gujarat were developed and standardized so as to incorporate maximum amount of fresh radish leaves using the Composite scores and Hedonic scores tests for organoleptic evaluation. These were: *dhebra* (shallow-fried) with 75 g of fresh radish leaves in 100 g of mix, *muthia* (steamed) with 75 g of fresh radish leaves in 100 g of mix and *handwa* (baked) with 40g of fresh radish leaves in 100 g of mix. The retention of β-carotene in these products was also estimated. The results showed that shallow-fried *dhebra* retained 82 %, followed by steamed and sauteed *muthia* (68 %) and *handwa* which called for prolonged heating, retained only 36 % of β-carotene. However, all the three products were nutrient dense with high amounts of both macro and micro nutrients and can be promoted to combat vitamin A deficiency as well as in the supplementaty feeding programmes to prevent overall malnutrition in the community.

Keywords : Cereal/pulse recipes, Food processing, Organoleptic evaluation, Radish leaves, Total and β-carotenes.

Food based strategy to combat vitamin A deficiency involves special considerations (Nambiar and Seshadri 2001) such as identifying optimal food sources of vitamin A and ensuring that they are prepared properly in order to retain their maximum vitamin A activity (Seshadri et al. 1996). Household processing of vegetables involves several steps such as washing, peeling, trimming, cutting, grinding, boiling, frying and steaming, during which they are often exposed to elevated temperatures, high or low pH levels, oxygen and light which accelerate the oxidative destruction of carotenoids and decrease their vitamin A activity (Jonsson 1990; Clydesdale et al. 1991). Thus the carotene content of unprocesed raw green leafy vegetables (GLVs) may not necessarily be indicative of how much carotene is consumed, and the question of how much β-carotene is retained at the point of consumption after processing needs to be established.

As of now systematic studies that have identified the different ways in which the carotene foods are processed in the households of Western Indian State of Gujarat are few. A survey by the present authors on the household methods of processing in 150 rural and urban households of the Vadodara and Panchmahal districts of Gujarat revealed that the most frequent household methods of processing the GLVs were sauteing, followed by pressure cooking, steaming, shallow-frying, boiling in a pan covered with lid and deep frying (Seshadri et al. 1996). Processing losses using three most commonly used methods indicated that small amount of oil used for sauting the GLVs namely colocasia leaves, onion stalks and radish leaves resulted in a greater retention of β-carotene when compared to pressure cooking and cooking with or without a lid (Seshadri et al. 1996). Studies on the retention of β-carotene from traditional recipes of Gujarat namely *muthia, dhebra* and *dal* soup with blanched and sulphited shade-dried drumstick leaves have shown a retention of 69, 73 and 35 % respectively (Seshadri et al. 1997).

Earlier studies in this laboratory by the authors have also reported that children preferred GLVs when incorporated into a cereal or a cereal/pulse based traditional recipe such as *dhebra, muthia, puda, bhajia*, etc. but generally had difficulty in accepting the GLVs in the form of a *bhaji* (Seshadri et al. 1996) similar to the results obtained by Devadas et al (1996). Therefore, these traditional recipes can be a better way of promoting GLVs in a community. Radish leaves which are commonly incorporated in the culturally accepted cereal-pulse based recipes of Gujarat were selected for the present study. These leaves have a β-carotene content of 6540 µg/100 g fresh weight (Nambiar and Seshadri 1998) and are rich in iron and calcium and have a low oxalic acid content (Table 1). The first objective of the present study was: to standardize (using organoleptic evaluations), three traditional recipes of Gujarat, so as to incorporate maximum amount of fresh radish leaves. The second objective was to study the retention of total and β-carotene of fresh radish leaves in these three different processing methods.

Materials and Methods

Selection of the recipes : In order to prepare β-carotene rich recipes and study their cooking losses, three products were developed using fresh radish leaves in a cereal/pulse mix namely-*dhebra* (shallow-fried chapati), *muthia* (steamed rolls which are sauteed) and *handwa* (baked savory dish). *Dhebra* is a form of chapati made of wheat, pearl millet flour

TABLE 1. CHEMICAL ANALYSIS OF FRESH RADISH LEAVES

Moisture, %	91.1 ± 0.34
Total carotene, µg/100 g FW	11930
β-carotene, µg/100 g FW	6540
β-carotene as % total carotene	54.8
Iron, µg/g DW	1.25 ± 0.02
Calcium, µg/g DW	29.3 ± 2.0
Phosphorus, µg/g DW	5.7 ± 0.16
Calcium : Phosphorus ratio	2.9 : 1
Ascorbic acid, µg/g DW	7.2 ± 0.20
Oxalic acid, µg/g DW	11.2 ± 0.79
Calcium : Oxalic acid ratio	2.62

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TABLE 2. INGREDIENTS AND THEIR AMOUNTS USED IN THE STANDARD RECIPES

Ingredients	Quantity, g
Dhebra	
Wheat flour	70
Bajra flour	30
Fresh radish leaves	75
Oil, as shorteneing	10
Oil, for shallow frying	10
Gingelly seeds	10
Jaggery	10
Garlic paste	10
Ginger paste	10
Green chilli paste	5
Lemon juice	10
Turmeric and salt	to taste
Muthia	
Cereal/pulse mix	100
(Rice:Redgram *dhal :Chana dhal*)	(3:1:1)
Fresh radish leaves	75
Oil, as shortening	10
Oil, for shallow frying	10
Gingelly seeds	10
Jaggery	10
Garlic paste	10
Ginger paste	10
Green chilli paste	5
Lemon juice	10
Turmeric and salt	to taste
Handwa	
Ceral/pulse mix	100
(Rice:Redgram *dhal:Chana dhal*)	(3:1:1)
Fresh radish leaves	40
Oil (for seasoning)	20
Gingelly seeds	10
Garlic paste	10
Ginger paste	10
Green chilli paste	5
Sugar	10
Tumeric and salt	to taste

(3:2) and GLV and spices. For preparation of *dhebra,* 75 g radish leaves were macerated using an electric mixture grinder and added to 100 g of wheat and pearl millet flour (3:2). Dough was prepared after addition of all the ingredients (Table 2). Two balls were rolled and the *dhebra* was sauteed on a hot tava using groundnut oil. *Muthia* are steamed-rolls prepared from a cereal-pulse combination with the incorporation of vegetables and spieces. These rolls are later cut into small pieces and seasoned with oil and spices. For preparation of *muthia,* 75 g of fresh radish leaves were macerated using electric mixture grinder and added to coarse flour mixture of rice: redgram *dhal:chana dhal* (3:1:1). Dough was prepared after addition of all the ingredients (Table 2). Rolls of 1" diameter was made and steamed in a pressure cooker for 10 min. When cool, these were cut into pieces and seasoned with groundnut oil using some spices. *Handwa* is a "baked savoury cake" prepared from fermented cereal-pulse batter (rice: redgram *dhal :chana dhal*-3:1:1), wherein various vegetables and spices are added. For preparation of *Handwa,* to 100 g of the coarse cereal-pulse mixture, salt was added and fermented for 8 h. Finely chopped fresh radish leaves were added to this batter along with other spices; the fermented batter was poured into the baking dish, seasoned with spices and baked at 180°C for 20 min.

Selection of sensory panelist and sensory evaluation : Using the triangle test, out of 15 members eight were selected for the organoleptic tests. Three samples of one recipe (*dhebra*) were offered to the members, two of which were similar (made from spinach) and one was different (mixture of spinach and radish leaves). The panelists were asked to identify the odd sample. These panel members with a masters or doctoral degree in Foods and Nutrition, were in good health and refrained from chewing gum or eating 30 min before the test. They were non-smokers and non-drinkers (Stone and Sidel 1993). In the composite scoring test, scores were given for various quality characteristics of the product, wherein the maximum scores were given for various quality characteristics of the product, wherein the maximum score was 5 for highly acceptable. Sensory evaluation was carried out on a 9-point Hedonic scale wherein score 9 was for "like extremely" and score I was for "dislike extremely".

Standardization of the three recipes : All the snacks were standardized at the Institution Management Laboratory of the Department of Foods and Nutrition. Fresh radish leaves from home garden were used for all the recipes. Different levels of fresh radish leaves in quantities equivalent to 2 RDA for pre-schoolers (1600 x 2 µg β-carotene), older children (2400 x 2 µg β-carotene) and lactating mothers (3000 x 2 µg β-carotene) were added to the basic ingredients and the recipes were subjected to acceptability trials by a panel of semitrained judges. The purpose of these trials was to determine the maximum amount of the fresh radish leaves that could be added to each of the recipe, without altering the sensory qualities and acceptability characteristics and at the same time determining how much RDA could be practically met through commonly eaten portions. As per the suggestions obtained from this preliminary organoleptic evaluation using a 5-point Composite scale and a 9-point Hedonic scale, the condiment and spice combination of the recipes were also

TABLE 3. ATTRIBUTE SCORES OF THE THREE RECIPES-COMPOSITE SCORES

Attributes	*Dhebra*	*Muthia*	*Handwa*
Appearance	4.5 ± 0.21	4.0 ± 0.45	3.2 ± 0.75
Colour	4.3 ± 0.16	4.2 ± 0.25	3.8 ± 0.89
Taste	4.6 ± 0.21	4.5 ± 0.22	4.5 ± 0.22
Texture	4.8 ± 0.10	4.4 ± 0.32	3.7 ± 0.33
After taste	4.5 ± 0.22	4.2 ± 0.37	4.1 ± 0.21
Overall acceptability	4.8 ± 0.17	4.6 ± 0.40	4.0 ± 0.17

Maximum score for each attribute is 5

All values are Mean ± S.E.

TABLE 4. RETENTION OF TOTAL AND BETA-CAROTENE IN THE THREE RECIPES

Product	Amount of radish leaves/ 100 g raw mix	Expected TC value mcg/100 g	TC/100g product	% retention TC	Expected BC value mcg/100 g	BC/100g product	% retention BC
Dhebra	75	8947.5	6696.18 ± 95.85	75	4905	4034.42 ± 71.49	82
Muthia	75	8947.5	6540.92 ± 46.67	73	4905	3359.6 ± 39.53	68
Handwa	40	4772.0	1194.00 ± 16.74	42	2616	942.24 ± 28.19	36

altered. Among all the recipes rated as extremely acceptable, the one which contained the highest levels of fresh radish leaves was selected for further sensory evaluation and chemical was analysis (Table 2).

Estimation of total and β-carotene of the three recipes: Total carotene and β-carotene were estimated using the method described in our previous paper (Nambiar and Seshadri 1998), which involved extraction using acetone and hexane, saponification using methanolic KOH, extration using petroleum ether and then reading on a spectrophotometer at 450 nm. HPLC analysis of β-carotene from the samples was carried out by injecting 20 µl of the extract on a stainless steel Microsorb ODS column (25 cm x 4.6 mm i.d.) with a 5 µm particle size, using the mobile phase as acetonitrile: dichloromethane: methanol. Standard β-carotene was generously donated by Haffman-La-Roche, Basel, Switzerland. All the solvents were of HPLC grade.

Statistical analysis : Appropriate statistical analysis such as means, standard deviations and ANOVA were done. (Snedecor and Cochran 1968).

Results and Discussion

Sensory attributes of the three recipes : The overall composite scores for *dhebra* (4.8 ± 0.17) was the best followed by *muthia* (4.6 ± 0.40) and *handwa* (4.0 ± 0.17) (Table 3). Score for the individual attributes for the three recipes ranged from 3.2 to 4.8. All the recipes were rated as "very good" by the panel of judges. The results of the Hedonic tests were similar to those of the composite scores (Table 3). Recent studies in this laboratory have obtained a Hedonic score of 8.0, 8.4 and 8.2 for dehydrated drumstick leaves recipes such as *dhebra, muthia* and *dhal* soup (Seshadri et al. 1997), similar to the results of the present study.

Retention of total and beta carotene on processing: As can be seen from Table 4, *dhebra* (shallow-fried) had the highest retention of 75 %, followed by *muthia* (steamed and sauteed) with the total carotene retention of 73 % but *handwa* (fermented and baked) retained the least amount of 42 %. Highest retention of β-carotene was also seen in *dhebra* (82 %), followed by *muthia* (68 %) and *handwa* (36 %). Thus, it appears from the data that shallow frying with oil with the shortest cooking time (~3 min), helped in maximum retention of total carotene. Steaming (~10 min), followed by sauteing (~1 min) in oil also resulted in a substantial amount of retention. This practice of using a little oil, week acids such as lemon juice and low heat have been shown to increase the stability of β-carotene (Premavalli et al. 1991). The greater loss in *handwa* could be ascribed to longer cooking time (20 min) at higher temperature (180°C).

Different practices in cooking such as boiling, steaming, stir-frying, frying and prolonged cooking have been reported to have varied effects on the retention of β-carotene (Madhavapeddi et al. 1994; Padmavati et al. 1992; Sood and Bhatt 1974; Reddy et al. 1995). Comparing the results obtained in the present study with those reported in the literature, it is found that Madhavapeddi et al (1994), reported a retention value of 71 % for sauteed and steamed spinach, and of 50 % when the vessel was covered with lid. Devadas et al (1996) have reported a range of 35 to 96.3 % for shallow-fat frying and 29.7 to 98.1 % for steaming for four different GLVs and corroborated that among boiling, steaming and shallow-fat frying, the last method of processing retained the maximum amount of β-carotene. Padmavati et al (1992) reported a β-carotene retention of 90.5 % for *methi thepla* and 57.3 % for *methi muthia.* Recipes which involves prolonged heating such as carrot and pumpkin *halwa* retained only 24.1 % β-carotene comparable to the results obtained in the present study.

The losses of total and β-carotene in the current study using three different methods of processing clearly demonstrate the liability of β-carotene to heat. Processing at elevated temperatures contribute to destruction of β-carotene by formation of compounds called ionenes (Sweeny and Marsh 1971). Although cooking procedures such as boiling may result in oxidative loss of carotenoids in some vegetables, heat treatments increased the chemical excitability in other methods. The presence of β-carotenoproteins in some vegetables may effect the heat stability and extractability of β-carotene and need to be studied.

Nutritive value of the recipes : As can be seen from Table 5, the nutritive value of the three recipes per serving

TABLE 5. NUTRITIVE VALUE OF THE THREE RECIPES PER SERVING AS PERCENT RDA FOR PRESCHOOLERS

	Dhebra (2 pieces)	*Muthia* (6 pieces)	*Handwa* (3 x 3" pieces)
Energy, Kcal	333.5	334.0	334.8
% RDA (1240 Kcal)	26.9	26.9	26.9
Proteins, g	9.0	8.2	8.2
% RDA (22 g)	40.8	37.2	37.2
Fat, g	13.8	13.1	13.1
% RDA (25 g)	55	52.4	52.1
Calcium, mg	132.9	121.4	73.9
% RDA (400 mg)	33.2	30.3	18.5
Iron, mg	8.0	5.9	3.9
% RDA (12 mg)	66.4	48.8	32.1
Vitamin C, mg	31.5	31.5	17.9
% RDA (40 mg)	78.8	78.8	44.6
β-carotene, µg	2052.38	1701.97	489.02
% RDA (600 µg)	128	106	30

provides approximately 27 % RDA for energy, 37-40 % for proteins, 13 % for fat, 18-33 % for calcium, 32-66 % for iron and 30-128 % for β-carotene after processing. Therefore these recipes which are rich in macro as well as the micro nutrients can be prepared and distributed in place of the existing supplementary feeding programmes. This will meet two goals: a) improved consumption of β-carotene rich foods as per the dietary diversification strategy (Gopalan et al. 1992) and b) meet the requirements for the protein-energy supplements as per the supplementary feeding programs of the Integrated Child Development Scheme.

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RESEARCH PAPER

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Quality of *Dudh Churpi* as Influenced by Moisture Content and Drying Conditions of Pre*churpi*

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Dudh churpi is a popular protein-rich milk product, traditionally consumed as a masticatory in the Eastern Himalayan parts, comprising Bhutan, Nepal, Tibet and India. Pre*churpi*, a partially dried intermediate in the process of making *dudh churpi*, was dried to different levels of moisture, and pieces of it were cooked in a standardized concentrated milk. On the basis of sensory evaluation, 30 % moisture level in pre*churpi* was observed to be most suitable for recooking. Exponential relationship was obtained between moisture ratio and time of drying of *dudh churpi* and Page's model fitted well to describe adequately the drying behaviour of *dudh churpi*. Highly significant coefficients of correlation ranging from 0.977 to 0.994 and a low (0.76 to 5.92) % root mean square indicated suitability of equations developed for prediction of drying time. While size of pre*churpi* had no significant effect on instrumental textural profile of *dudh churpi*, temperature of drying beyond 35°C significantly affected the texture. The product obtained by drying at 35°C was similar to the best available product in markets.

Keywords : Pre*churpi*, *Dudh churpi*, Cooking, Drying, Moisture ratio.

Sun-drying of foodstuffs was a well recognized traditional method for preservation of food until the turn of the 20th century. Thereafter, mechanical drying began to replace sun-drying. Innovation in the existing methods of drying is taking place constantly with a view to keep wholesomeness in the final product (Chaudhuri et al. 1993).

Dudh churpi is made from milk of yak or cow and is stable for several months without refrigeration. Drying, recognized as a classical method for preservation of highly nutritious milk solids especially milk proteins, in combination with other hurdles like heating, acid coagulation, addition of sugar, smoking and packaging makes *dudh churpi* shelf stable (Hossain 1995; Leistner 1999).

Traditionally, pre*churpi* is prepared by coagulating partially skimmed milk. The coagulum is cooked and then pressed heavily overnight. The pieces of coagulum are partially dried in kitchen over the warmth of a wood-fired oven for 25-30 days (Pal et al. 1993). Thus prepared pre*churpi* is cooked for 15-25 min in concentrated milk containing a little amount of sugar, and the contents are cooled to room temperature. The cooked pre*churpi* is dried in kitchen for 15-25 days. Therefore, drying is an important integral step of manufacturing the product and influences its quality. Traditional drying of *dudh churpi* is inherently slow, non-uniform, time consuming and labour intensive (Hossain 1995). Drying of pre*churpi* in a mechanical dryer would shorten the time of production and enhance the quality of the product.

The present experiment was designed to determine the optimum moisture level of pre*churpi* at different drying conditions suitable for cooking in concentrated milk, to examine the effect of shape, size and drying temperature on the textural quality of *dudh churpi*, and to study the drying behaviour and predict drying time from the equations developed.

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Materials and Methods

*Preparation of pre*churpi : Cow's milk, obtained from the Himalayan Co-operative Milk Producers' Union Limited (HIMUL), Matigara, West Bengal, India, was standardized to 1.0 % (w/w) fat and 8.7 % (w/w) solids-not-fat (SNF), heated to 70°C, and coagulated within 60 s using hot (70°C) 2% (w/v) citric acid solution. The whey was removed by instant filtering through a muslin cloth. The coagulum was cooked in a stainless steel container over hot water bath and pressed at 9 kg cm^{-2} for 12 h to make pre*churpi* (Pal et al. 1996).

*Drying of pre*churpi : The pressed coagulum was cut into a number of pieces of equal size (4 cm x 2 cm x 2 cm) and smoked for 30 min with wood charcoal. The traditional drying was continued over wood fire following the standard method (Pal 1994). For controlled drying, convection air current type drying chambers maintained at 35°, 40° and 45°C were used. Relatively low temperatures were used because it was known from the preliminary trials that the product became so hard and fragile above 50°C that it was unacceptable by sensory panelists. The traditional drying as well as oven drying were used to dehydrate the product to the moisture levels of 25, 30, 35 and 40 %. The products were then cooked for 15 min in concentrated milk containing 2.50 % fat, 21.75 % SNF, 5.00 % sucrose and 29.25 % total solids (Hossain et al. 1998, 1999 a, 1999 b). The drying was continued further under conditions mentioned earlier till the product attained a specifically controlled moisture content of 15.4 %. The samples of *dudh churpi*, thus prepared, were subjected to sensory evaluation.

*Effect of size and shape on behaviour of pre*churpi : The cooked and pressed mass of coagulum was cut into different sizes and shapes using a knife. The pieces were smoked, dried to 30.0 % moisture content, and cooked in the standardized concentrated milk. The product was dried using the traditional method of drying and also chamber drying, till

TABLE 1. EFFECT OF MOISTURE LEVEL OF PRE*CHURPI* FOR COOKING AND TEMPERATURE OF DRYING ON THE SENSORY QUALITY OF *DUDH CHURPI*

Moisture, %	Drying temperature[a], °C	Sensory score[b] Flavour	Body and texture	Colour and appearance	Total
40	AT	4.61 ± 0.06	5.04 ± 0.06	2.28 ± 0.05	11.92 ± 0.08
	35	4.79 ± 0.04	5.11 ± 0.03	2.32 ± 0.06	12.21 ± 0.11
	40	4.28 ± 0.05	4.79 ± 0.04	2.07 ± 0.03	11.14 ± 0.09
	45	4.36 ± 0.04	4.50 ± 0.03	1.90 ± 0.03	10.75 ± 0.03
35	AT	7.28 ± 0.05	6.97 ± 0.06	3.43 ± 0.05	17.68 ± 0.09
	35	7.32 ± 0.06	7.04 ± 0.06	3.46 ± 0.06	17.82 ± 0.16
	40	7.07 ± 0.03	6.21 ± 0.03	3.36 ± 0.04	16.64 ± 0.04
	45	6.79 ± 0.04	5.97 ± 0.06	2.21 ± 0.03	14.96 ± 0.09
30	AT	8.36 ± 0.04	8.00 ± 0.05	4.82 ± 0.03	21.28 ± 0.03
	35	8.28 ± 0.05	8.07 ± 0.08	4.79 ± 0.04	21.14 ± 0.05
	40	7.90 ± 0.03	7.69 ± 0.02	3.79 ± 0.04	19.37 ± 0.07
	45	7.47 ± 0.03	7.50 ± 0.04	3.21 ± 0.03	18.18 ± 0.06
25	AT	7.50 ± 0.03	7.25 ± 0.06	3.47 ± 0.03	18.21 ± 0.04
	35	7.54 ± 0.06	7.32 ± 0.06	3.47 ± 0.03	18.32 ± 0.09
	40	6.97 ± 0.06	6.68 ± 0.03	2.61 ± 0.06	16.25 ± 0.10
	45	6.75 ± 0.03	6.39 ± 0.03	2.11 ± 0.03	15.24 ± 0.08
CD (P<0.05)		0.14	0.15	0.14	0.28

[a]Ambient temperature (AT) (26-44°C), RH 67-27 %

[b]Data represent the means ± SEM of four replicates

it attained the moisture content of 15.4 %. The maximum and minimum temperatures of drying and relative humidities at different days of drying were recorded and are presented in Table 1. The samples were subjected to instrumental textural profile analysis (TPA). During drying, every alternate day, 20 g samples were drawn from each lot and analysed for moisture by gravimetric method (AOAC 1990).

Sensory analysis : The product samples were subjected to sensory evaluation by a panel of seven trained judges for overall sensory quality using a 25-point score card consisting of flavour (10), body and texture (10), and colour and appearance (5) (Hossain et al. 1996). All evaluations were conducted in quadruplets.

Statistical analysis : Data on sensory attributes and objective textural parameters were analysed using two-way factorial design (Snedecor and Cochran 1989). The model suggested by Page (1949) was used to determine the drying characteristics of *dudh churpi.*

Textural profile analysis : An Instron Universal Testing Machine (model 4301, Instron Ltd, UK), fitted with a 1000 N load cell, was used to carry out the TPA of *dudh churpi.* Cubical (5 mm x 5 mm x 5 mm) samples were subjected to uniaxial compression by 20 % of initial sample dimension.

The force-distance curve, obtained for a two-bite deformation cycle employing a cross-head speed of 50 mm min^{-1}, was used to determine the different parameters at 30°C (Brady et al. 1985). The values were expressed for total cross sectional area (mm^2) of the samples.

Results and Discussion

Dudh churpi samples made from pre*churpi* containing 25, 35 and 40 % moisture, and cooked and dried at different temperatures rated lower with respect to sensory attributes than the samples made from 30 % moisture level pre*churpi*, cooked and dried either by traditional method or at 35° and 40°C (Table 1). Significant (P<0.05) difference was not observed in quality of the product cooked at 30 % moisture level and dried at ambient temperature (to mimic the traditional method) and also at 35°C. Statistical analysis of the processing factors showed that the interactions among moisture levels and drying temperatures and between them were highly significant (P<0.01) for all the sensory attributes studied (Table 2). This indicates that the drying temperature and initial moisture content of pre*churpi* jointly influenced the sensory quality of *dudh churpi.*

Pre*churpi* of 40 and 35 % moisture levels, dried at different temperatures, had significantly (P<0.05) lower scores with respect to all the sensory attributes compared to the pre*churpi* of 30 and 25 % moisture levels. This could be attributed to low concentration of osmotic solution of the

TABLE 2. ANALYSIS OF VARIANCE FOR SENSORY SCORES

Sources of variation	Degrees of freedom	Mean sum of squares[a] Flavour	Body texture	Colour and appearance	Total score
Among moisture levels (M)	3	36.84	24.51	10.97	198.10
Among drying temperatures (T)	3	1.53	2.31	4.80	24.28
Interaction (M x T)	9	0.07	0.08	0.37	0.73
Error	45	0.01	0.01	0.01	0.04

[a]Significant at P<0.01

TABLE 3. DRYING BEHAVIOUR OF *DUDH CHURPI* EVALUATED FROM PAGE'S MODEL

Drying temperature[a], °C	Size[b]	Equation developed	Coefficient of correlation	Time of half response ($t_{1/2}$), days	Drying time, days	% RMS
AT	A	MR = exp ($-0.113t^{1.059}$)	0.993	5.526	33.03	1.26
	B	MR = exp ($-0.103t^{1.087}$)	0.992	5.753	32.82	1.62
	C	MR = exp ($-0.093t^{1.095}$)	0.994	6.235	35.11	1.34
35	A	MR = exp ($-0.237t^{1.072}$)	0.982	2.721	15.92	3.78
	B	MR = exp ($-0.253t^{1.049}$)	0.977	2.067	15.85	4.90
	C	MR = exp ($-0.220t^{1.036}$)	0.974	3.021	18.78	5.92
40	A	MR = exp ($-0.281t^{1.179}$)	0.993	2.190	10.71	1.21
	B	MR = exp ($-0.284t^{1.139}$)	0.993	2.190	11.54	0.99
	C	MR = exp ($-0.270t^{1.140}$)	0.989	2.284	12.02	1.86
45	A	MR = exp ($-0.269t^{1.338}$)	0.993	2.025	8.34	0.76
	B	MR = exp ($-0.258t^{1.340}$)	0.990	2.087	8.27	1.10
	C	MR = exp ($0.248t^{1.378}$)	0.987	2.109	8.33	1.65

[a]Ambient temperature (AT) (26-44°C), RH 67-27 %; RMS = Root Mean Square

[b]A, cylindrical (2.2 cm x 2.1 cm dia); B, rectangular (4.0 cm x 2.0 cm x 1.0 cm); C, rectangular (3.0 cm x 2.0 cm x 2.3 cm)

samples, since equilibrium and adsorption rates increase in osmotic sugar concentration (Rahaman 1992). Poor sensory scores ($P<0.05$) in the samples of *dudh churpi*, cooked at 25 % moisture level than the samples cooked at 30 % moisture level could be explained by the loss of membrane integrity or change in the pore size due to prolonged heating (Rahaman 1992). Thus, 30 % moisture level in pre*churpi* was found optimum for its cooking in standardized concentrated milk.

The moisture content variation during drying was monitored by the formula of material balance, $Q_1 (100-M_1) = Q_2 (100-M_2)$, where Q_1 and Q_2 are initial and final weights in g, and M_1 and M_2 are moisture contents at Q_1 and Q_2. The rate of drying was expressed by the model (Page 1949).

$$MR = \frac{M_1 - M_e}{M_0 - M_e} = \exp(-K_1 . t^{K2})$$

where, MR is moisture ratio, M_1 is moisture content at time t, M_e is equilibrium moisture and M_0 is initial moisture content. K_1 and K_2 are the drying constants evaluated by linear regression after logarithmic transformation to the form

$$\ln(-\ln MR) = \ln K_1 + K_2 \ln t$$

Drying rate curves showing moisture ratio versus time of drying under four different temperatures with three different sizes of *dudh churpi* are shown in Fig. 1. The data on drying behaviour of *dudh churpi* were recorded only after cooking pre*churpi* of 30 % moisture level. Drying rate curves for all three sizes at four different temperatures exhibited a similar rate of drying for initial 2 days. Higher rate of drying at this period may be attributed to the higher moisture potential available at the surface of samples for evaporation (Pal 1994).

However, the drying rate (dM/dt) was less in the samples of larger size, i.e. the dM/dt value was less in a sample of rectangular shape having 13.8 cm^3 volume than that of 8.0 cm^3 sample or the cylindrical one of 7.6 cm^3 (Fig. 1). The rate decreased as a function of time of drying. This phenomenon may be attributed to the fact that drying rate depends on the mass transfer coefficient, drying surface area, water vapour

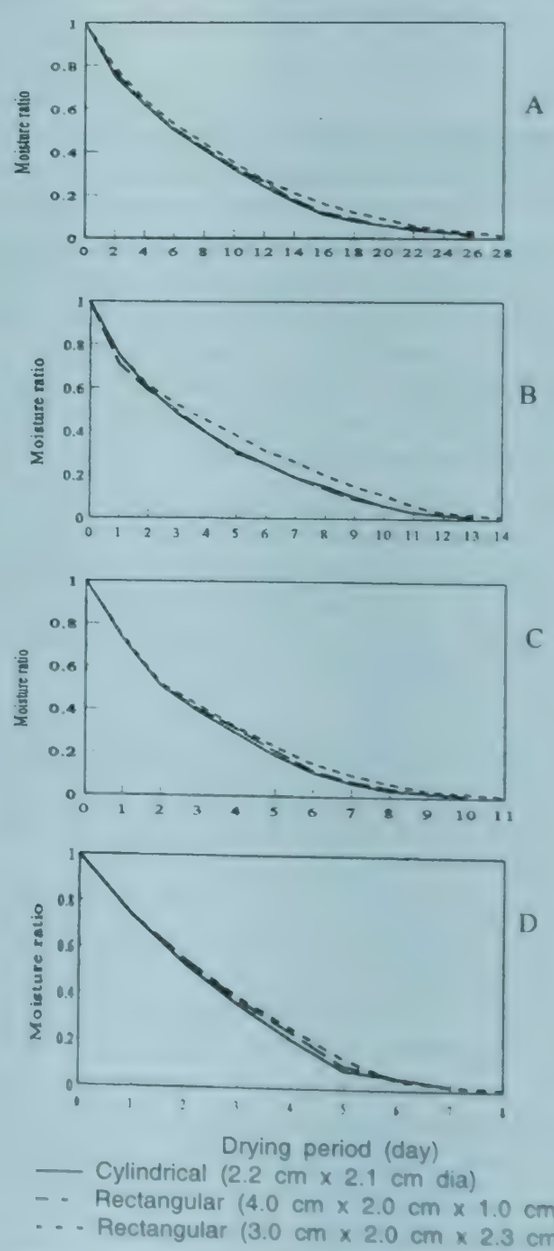

Fig. 1. Effect of size and period of drying of pre*churpi* at ambient temperature (A), 35°C, (B) 40°C (C) and 45°C (D) on drying behaviour of *dudh churpi*

TABLE 4. EFFECT OF SIZE AND DRYING TEMPERATURES ON INSTRON PARAMETERS OF *DUDH CHURPI*

Drying temperature[a], °C	Size[b]	Instron parameter[c] Hardness, N	Cohesiveness	Springiness, mm	Gumminess, N	Chewiness, N.mm
AT[a]	A	363.00 ± 4.03	0.59 ± 0.01	0.68 ± 0.03	214.30 ± 5.59	145.21 ± 9.62
	B	362.00 ± 2.89	0.60 ± 0.01	0.71 ± 0.03	216.33 ± 4.22	153.79 ± 1.67
	C	365.35 ± 2.22	0.61 ± 0.01	0.69 ± 0.02	222.55 ± 3.87	153.23 ± 6.82
35	A	364.00 ± 2.37	0.60 ± 0.01	0.73 ± 0.01	218.33 ± 2.35	158.24 ± 2.50
	B	364.75 ± 2.41	0.62 ± 0.01	0.68 ± 0.01	224.29 ± 1.69	151.39 ± 2.95
	B	365.00 ± 3.18	0.61 ± 0.01	0.73 ± 0.01	221.63 ± 2.10	160.72 ± 3.59
40	A	374.50 ± 1.03	0.61 ± 0.01	0.54 ± 0.02	229.38 ± 2.87	123.33 ± 5.25
	B	372.50 ± 0.56	0.60 ± 0.01	0.58 ± 0.01	224.41 ± 3.28	129.11 ± 3.99
	C	375.00 ± 0.35	0.62 ± 0.01	0.56 ± 0.02	230.62 ± 1.96	129.58 ± 3.84
45	A	402.50 ± 1.48	0.43 ± 0.01	0.35 ± 0.02	173.15 ± 5.72	60.95 ± 4.88
	B	404.25 ± 1.78	0.44 ± 0.01	0.36 ± 0.02	175.82 ± 1.79	63.60 ± 3.11
	C	403.75 ± 1.43	0.43 ± 0.11	0.38 ± 0.01	173.67 ± 5.07	65.12 ± 2.91
CD (P<0.05)		7.62	0.01	0.06	6.67	14.87
CD (P<0.01)		10.24	0.01	0.08	9.08	19.98

[a]Ambient temperature (AT) (26-44°C), RH 67-27 %

[b]A, cylindrical (2.2 cm x 2.1 cm dia); B, rectangular (4.0 cm x 2.0 cm x 1.0 cm); C, rectangualr (3.0 cm x 2.0 cm x 2.3 cm)

[c]Data represent the means ± SEM of four replicates

TABLE 5. ANALYSIS OF VARIANCE FOR INSTRON VALUES

Sources of variation	Degrees of freedom	Mean sum of squares Hardness	Cohesiveness	Springiness	Gumminess	Chewiness
Among sizes (S)	3	8.7233	0.000130	0.00070	29.75	72.96
Among drying temperatures (T)	3	4159.25[a]	0.091000[a]	0.30670[a]	7197.15[a]	21975.85[a]
Interaction (S x T)	9	4.0000	0.000122	0.00130	25.81	31.63
Error	33	28.0478	0.000040	0.00182	22.09	106.83

[a]Significant at P<0.01

pressure at product surface and partial pressure of water vapour in drying air (Brennan et al. 1990).

At the onset of drying, as the drying interface recedes to the interior, its distance increases and the moisture movement within solids occurs through liquid vapour diffusion only from the upper side, which is exposed to the drying air (Hallstrom 1990). The rate of drying decreased as the replenishment of water from interior to the surface of pre*churpi* could not cope up with the fast removal of moisture from the surface. An increase in drying temperature reduced the drying time because increase in drying temperature increased the rate (dM/dt) for all sample sizes. The drying rate at all temperatures became less during final stages of drying which may be due to increase in concentration of sugar and protein, thereby increasing water binding capacity of the samples (Rahaman and Lamb 1991).

The constants K_1 and K_2 are found to depend on temperature and relative humidity in case of traditional drying. These constants can be expressed for *dudh churpi* drying in form as

$$K_1 = 0.389 - 0.11T + 0.002RH$$

$$K_2 = 0.267 + 0.02T + 0.002RH$$

where T denotes temperature in °C and RH, the relative humidity.

The effect of size on the rate of drying of *dudh churpi* can be evaluated by considering the time of half response ($t_{1/2}$). The $t_{1/2}$ is defined as the time required to remove the first half of the free moisture. This corresponds to the time required to reach a moisture ratio of 0.5. Drying equations, $t_{1/2}$ and predicted drying period as evaluated by the Page's model with percent root mean square (%RMS) are presented in Table 3. This shows that rate of drying was higher for smaller sizes of *dudh churpi* and the drying increased with the increase in temperature. The fitness of Page's equation to the data was tested by calculating % RMS which lies between 1.26 and 1.62 in case of traditional drying and between 3.78 and 5.92, 0.99 and 1.86, and 0.76 and 1.76 during mechanical drying at 35°, 40° and 45°C, respectively. These low % RMS indicate that the Page's model fits well to the data. Ajibola et al (1988) adequately expressed drying data on pregelled yam by Page's model. Muthu and Chattopadhyay (1992) also suitably presented thin layer drying characteristics of parboiled rice using the Page's model.

The objective textural profile of *dudh churpi* of three different sizes dried at four different temperatures is shown in Table 4 and its statistical analysis is presented in Table 5. The size of *dudh churpi* had no significant effect on its body and textural characteristics. However, the increase in drying temperature beyond 35°C adversely altered the texture of *dudh*

churpi. Significant ($P<0.05$) increase in hardness but decrease in cohesiveness, springiness, gumminess and chewiness was observed in drying temperatures beyond 35°C. The interactions between sizes and temperatures were not significant.

The samples of *dudh churpi* exhibited no significant ($P<0.01$) difference with respect to all the Instron parameters when dried traditionally and in a drying chamber at 35°C. The data on Instron parameters of *dudh churpi* dehydrated at 35°C also resembled closely with the best available market samples of Bhutan (Hossain 1995).

It can be concluded from this investigation that best quality *dudh churpi* could be prepared when smoked pieces of pre*churpi* were dried in an oven at 35°C to a moisture level of 30 %, cooked for 15 min in concentrated milk containing 2.5 % fat, 21.75 % SNF, 5.00 % sucrose and 29.25 % total solids and further dried in an oven at 35°C for 15-20 days.

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RESEARCH PAPER

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Composition and Functional Properties of Fermented Soybean Flour (*Kinema*)

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Kinema samples prepared by traditional and aseptic pure culture method were dried and ground to fine flour. Full fat and low fat soy flours were also prepared. The chemical, functional and sensory properties of all these four products were determined. While there were little changes in protein and total fat contents during fermentation, free fatty acids increased substantially. Crude fibre and total sugar contents were reduced with a simultaneous increase in reducing sugars. On the other hand, water and oil retention capacity, gelation, foaming capacity and urease activity of *kinema* flours were lower than soyflours, while emulsifying activity, bulk density, viscosity and particle size were higher for *kinema* flours. Nitrogen solubility index was high in *kinema* flours at 64.3 % and 66.0 % for traditional and pure culture *kinema* products, respectively. *Kinema* flours were significantly ($P \leq 0.05$) darker, more reddish and yellowish than soyflours.

Keywords : Soybean, *Kinema, Bacillus* fermentation, Soyflours, Proximate analysis, Functional properties.

Kinema is a non-salted, solid state traditional fermented soy food consumed in the Eastern Hills of Nepal, Darjeeling Hills of West Bengal and Sikkim in India. It has a pungent smell of ammonia, slimy texture and short shelf life, in many ways similar to natto of Japan and thua-nao of Thailand (Sarkar and Tamang 1994; Karki 1986). Because of its unique flavour and appearance, *kinema* is produced and consumed only in certain localities where its taste is favoured. Traditionally, *kinema* is prepared by washing, soaking, boiling till beans are softened, craking, wrapping the beans with banana or fern leaves and fermenting in a bamboo basket for 1 to 2 days. A small amount of fire wood ash is often added. Karki (1986), Sarkar et al (1994) and Sarkar and Tamang (1994) have investigated the effect of process variables, proximate composition and microflora of *kinema* and have reported that *Bacillus subtilis* is the most dominant fermenting organism for *kinema* production.

Natto, a Japanese counterpart of *kinema,* is nutritious and easily digestible with many important physiological roles in the body (Liu 1997). In Japan, dry natto powder has been successfully incorporated in biscuits, crackers and soup mix (Watanabe 1969). *Kinema* flour has the potential to be used as a possible protein enrichment medium for cereal based-foods. The behaviour of *kinema* flour in food systems depends on their physiochemical properties. This work was done to prepare *kinema* by traditional as well as improved methods, to study the chemical and functional properties of the dry powder, and to compare them with full fat soyflour (FFSF) and low fat soyflour (LFSF).

Materials and Methods

Preparation of soy and kinema flours : Seeds of an indigenous Nepalese cultivar of soybean (*Glycine max* (L.) cultivar 'local yellow') were dehulled by drying the bean at 80°C for 2 h in a cabinet drier (Reico, QID/5, India), cooling and milling in a hammer mill (Asoka 16, India) with a wider milling gap and finally winnowing. Dehulled beans were soaked for about 1 h, drained, boiled for 45 min and dried in a cabinet drier to a moisture content of about 7 %. Dried beans were ground in a hammer mill to produce FFSF. LFSF was prepared by expressing oil from dehulled beans, using a locally made mechanical oil expeller and grinding the dried cake in a hammer mill.

Kinema was prepared traditionally under the optimized process conditions described by Sarkar and Tamang (1994). *Kinema* was also prepared by aseptic method according to Sarkar and Tamang (1995). *Bacillus subtilis,* previously isolated from *kinema* was obtained from Central Food Research Laboratory, Kathmandu, Nepal, was used as inoculum. The fermented soybeans, both prepared from traditional and pure culture method, were dried in a cabinet drier at 65-70°C for 10 to 12 h to a moisture content of about 6%, and ground to a smooth flour, denoted as traditional *kinema* flour (TKF) and pure culture *kinema* flour (PKF), respectively.

Chemical analysis : The products were analyzed for moisture content, crude oil (Soxtec system HT 2), total and reducing sugars and pH value (Systronics type 335 pH meter) (Egan et al. 1981). Total dietary fibre was estimated according to Ranganna (1977) and total ash by AOAC (1995) method. The crude protein as N x 6.25 was determined by the Kjeldahl method (AOAC 1995). The total carbohydrate content of the samples was calculated by difference (Ranganna 1977). Energy (kJ) was calculated applying the factors, 17, 37 and 17 for each gram of protein, lipid and carbohydrate, respectively (Greenfield and Southgate 1992).

Functional properties : Bulk density and wettability were determined according to Ozekie and Bellow (1988). Emulsifying activity index (EAI) was determined according to Mutilangi et al (1996). Gelation properties were determined according to Coffman and Garcia (1977). Foam capacity or whippability and foam stability were determined according to Coffman and Garcia (1977). Water and oil retention capacities were measured according to Beuchat (1977). The activity of the

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residual urease in the soybean products was determined according to Smith and Circle (1978). Colour was measured by a Colour Difference Meter (Model TC-PIIIA, Tokyo Denshoku, Co., Ltd) using the 'L' (lightness), 'a' (redness) and 'b' (yellowness) scales and hue. Protein solubility profile was determined at different levels of pH according to Sathe et al (1982) and Franzen and Kinsella (1976). Protein in the supernatant was quantified by the biuret (Umbreit et al. 1972) using a spectrophotometer (Model PYE UNICOM PU 8685, USA). Means of triplicates were calculated and expressed as mg protein per mL of water. The solubility profile was obtained by plotting protein solubility versus pH where the solubility at pH 12 was 100 %. Nitrogen solubility index (NSI) was measured according to the following procedure: Five grams of isolated protein were dispersed in 200 ml distilled water. Dispersion was stirred continuously with a magnetic stirrer for 2 h at room temperature. The resulting mixture was then centrifuged at 15000 rpm for 10 min. The supernatant was analyzed for total nitrogen by Kjel dahl method (AOAC 1995). NSI was calculated according to Smith and Brekke (1984).

$$\text{NSI (\%)} = \frac{\text{\% soluble nitrogen in water}}{\text{\% total nitrogen of sample}} \times 100$$

Statistical analysis : One way analysis of variance and least significance difference (LSD) comparison test of MRT (Multiple Range Tests) (Statistical Graphics Corporation, 1993, Manugistics Inc., USA) were used to interpret difference in means, if any of each of three individual treatment replications, at the 95% confidence level.

Results and Discussion

Chemical analysis : The data for proximate analyses of the four flours are shown in Table 1. Comparison with FFSF showed that there were 4.9 % and 2.2 % increases in protein contents for TKF and PKF, respectively. Nikkuni et al (1995) reported a 7.78 % increase in protein content during *kinema* production. Sarkar and Tamang (1995) also reported increase in total nitrogen content in *kinema.* While oil, ash as well as energy values remain unchanged, and crude fibre markedly reduced. *Bacillus* produces many carbohydrate-splitting enzymes, which may have hydrolyzed the polysaccharides lowering the crude fibre level (Priest 1989). The *kinema* production process reduced the total sugar level with a simultaneous increase in reducing sugar level. Sarkar et al (1997) reported that heating and *Bacillus* fermentation are accompanied by degradation of oligosaccharides e.g., raffinose and stachyose, thus eliminating a potential cause of flatulence for consumers.

The free fatty acid values of both TKF and PKF increased markedly, 4.6 and 9 times, respectively. Sarkar et al (1994) reported a 33-fold increase in free fatty acids value of *kinema* as compared to raw soybean, suggesting release of lipase during the fermentation process. The pH values of the products were significantly different ($P \leq 0.05$) with FFSF having the highest value followed by LFSF, TKF and PKF in decreasing order (Table 2). In contrast, Sarkar and Tamang (1995) reported that fresh *kinema* had a pH of about 8.4. Heating (drying) of fresh *kinema* that removed ammonia and disturbs the buffering system might have reduced the pH value in food.

Functional properties : The values for bulk density of the products were significantly ($P \leq 0.05$) different. The values obtained for these samples were higher than those reported

TABLE 1. PROXIMATE COMPOSITION OF SOY AND *KINEMA* FLOURS

Properties	FFSF	LFSF	TKF	PKF
Moisture, %	6.62 ± 0.11	8.20 ± 0.12	7.22 ± 0.12	6.80 ± 0.11
Proteins, %	44.08 ± 0.99	51.68 ± 1.23	46.25 ± 1.13	45.06 ± 0.98
Lipids, %	21.85 ± 1.37	6.70 ± 0.28	22.23 ± 2.46	23.02 ± 1.69
Ash, %	4.73 ± 0.10	5.44 ± 0.12	4.83 ± 0.12	4.47 ± 1.09
Total carbohydrate, %	29.85 ± 2.09	30.18 ± 2.74	26.31 ± 1.56	27.35 ± 2.12
Crude fibre, %	6.50 ± 0.46	7.50 ± 0.24	4.20 ± 0.46	4.80 ± 0.25
Total sugars, %	21.00 ± 1.11	23.81 ± 1.22	14.49 ± 1.14	16.50 ± 1.11
Reducing sugars, %	3.10 ± 0.12	3.52 ± 0.22	5.08 ± 0.22	4.68 ± 0.19
Energy, MJ/100 g	1.91 ± 0.02	1.53 ± 0.01	1.86 ± 0.02	1.89 ± 0.02
Free fatty acids, %	0.70 ± 0.01	-	3.15 ± 0.01	6.17 ± 0.07

Data represent means of triplicates ± standard deviation. All calculations are based on dry matter basis.

TABLE 2. SOME FUNCTIONAL PROPERTIES OF SOY AND *KINEMA* FLOURS

Properties	FFSF	LFSF	TKF	PKF
Bulk density, g/ml	$0.56^{a} \pm 0.01$	$0.79^{d} \pm 0.01$	$0.64^{b} \pm 0.00$	$0.69^{c} \pm 0.00$
Water binding capacity, g/g	$3.51^{c} \pm 0.05$	$3.52^{c} \pm 0.90$	$2.77^{b} \pm 1.10$	$2.51^{a} \pm 0.01$
Oil binding capacity, g/g	$2.42^{d} \pm 0.03$	$1.95^{b} \pm 0.02$	$2.00^{c} \pm 0.03$	$1.86^{a} \pm 0.06$
Wettability, min	$0.38^{a} \pm 0.08$	$0.37^{a} \pm 0.07$	$0.35^{a} \pm 0.10$	$1.11^{b} \pm 0.02$
Emulsifying activity index,m^2/g	$4.71^{a} \pm 0.05$	$5.66^{b} \pm 0.09$	$8.20^{c} \pm 0.03$	$8.46^{d} \pm 0.38$
Urease activity	0.023 ± 0.01	1.02 ± 0.00	1.02 ± 0.00	0.015 ± 0.01
Nitrogen solubility index, %	$17.07^{a} \pm 1.00$	$29.19^{b} \pm 0.89$	$64.32^{c} \pm 1.07$	$66.02^{c} \pm 0.95$
pH	$6.93^{d} \pm 0.01$	$6.90^{c} \pm 0.01$	$6.63^{b} \pm 0.02$	$6.55^{a} \pm 0.00$
Foam volume increase, %	$8.07^{b} \pm 0.67$	$22.00^{c} \pm 0.70$	$7.97^{b} \pm 0.30$	$6.06^{a} \pm 0.32$
LGC*,% w/v	22.00	20.00	NG	NG
L*	$84.24^{a} \pm 0.62$	$76.69^{d} \pm 0.56$	$70.22^{c} \pm 0.34$	$58.71^{b} \pm 1.09$
a*	$0.54^{a} \pm 0.14$	$2.32^{a} \pm 0.09$	$9.026^{b} \pm 0.41$	$13.34^{c} \pm 1.84$
b*	$26.50^{a} \pm 1.15$	$27.44^{a} \pm 2.18$	$32.72^{b} \pm 0.26$	$35.95^{c} \pm 0.87$
Hue	88.84	86.16	77.20	69.66

Significance of LSD test of treatment means at $P \leq 0.05$ and standard deviation. Means with the same superscript within same row are not significantly different. *Mean of six samples, otherwise means of triplicates. *LGC, Least gel concentration and NG, no gelation

for defatted soyflour 0.382 g/ml by Hassan and Abou-Arab (1993). The high-pressure extraction of oil might have a densification effect on LFSF. The formation of gummy materials on the surface of the beans due to *Bacillus* fermentation might have contributed greater inter-particle adhesion in *kinema* flour. The wettability of PKF was significantly ($P \leq 0.05$) higher than of the three other flours (Table 2). Autoclaving might have affected the surface activity and porosity of particles, causing higher wettability.

The emulsifying activity indices of flour samples were significantly ($P \leq 0.05$) different. PKF was the highest followed by TKF, LFSF and FFSF in decreasing order (Table 2). McWatters and Holmes (1979) reported that the emulsion capacity of soyflour was reduced when heating time was increased; a 22 % reduction after 20 min of heating. Liu (1997) observed that the emulsifying capacity of soy protein products increased with increasing protein solubility.

While there was no gel formation by *kinema* flours, soyflours formed gel at 20 % (Table 2). The values were lower than the least gelling concentration (LGC) of protein isolates at 8 % (Liu 1997). The low gelling ability of these products might be due to coarser texture or the presence of large amounts of impurities as lipid, denatured protein and polysaccharides.

Data on the foaming capacity of soy and *kinema* flours indicated that LFSF had the highest foaming capacity ($P \leq 0.05$), well above that of PKF, with FFSF and TKF in between (Table 2). Lin et al (1974) reported a foaming capacity of 70 % for soyflours. Yatsumatsu et al (1972) reported the denaturation of protein during processing; and also the lipid materials in soy preparations were very detrimental to foaming because they destabilized protein films. The stability of foam resulting from PKF was the least, and total collapse occurred within 2 h (Fig. 1).

Water retention capacity is an index of the amount of water retained within a protein matrix or other system under certain conditions. Water retention by the *kinema* flours was significantly ($P \leq 0.05$) lower than that by soyflours (Table 2). The difference in values might have been caused by physical and chemical modifications of the protein structure caused by heating and fermentation. Fleming et al (1974) reported similar water holding capacities of 2.6 g/g, 2.75 g/g 6.25 g/g of solids for soyflour, soy-concentrate, and soy-isolate, respectively. The oil retention capacity of all products was significantly ($P \leq 0.05$) different; while FFSF was found to have the highest, and PKF had the lowest oil retention value. Lin et al (1974) reported oil holding capacities of 1.84 g/g, 2.33 g/g, and 1.92 g/g of solids for soyflour, and commercial soy protein concentrates (Isopro and Promosoy), respectively. The amount of oil bound to flours was markedly affected by the method of determination, the nature and amount of protein content, surface area, charge and topography, hydrophobicity, and the liqidity of oil (Kinsella et al. 1985).

The urease activity test indicated that all the samples, except LFSF, were properly cooked to inactivate the trypsin inhibitor and other biologically active enzymes (Table 2). The

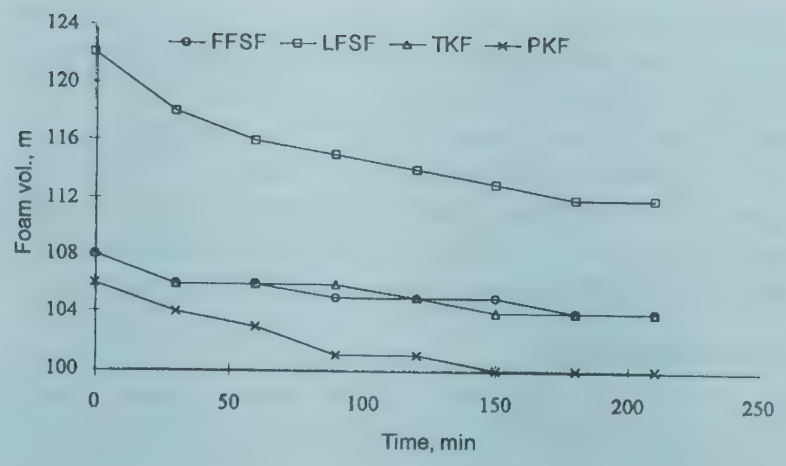

Fig. 1. Foam stability of soy and *kinema* flours

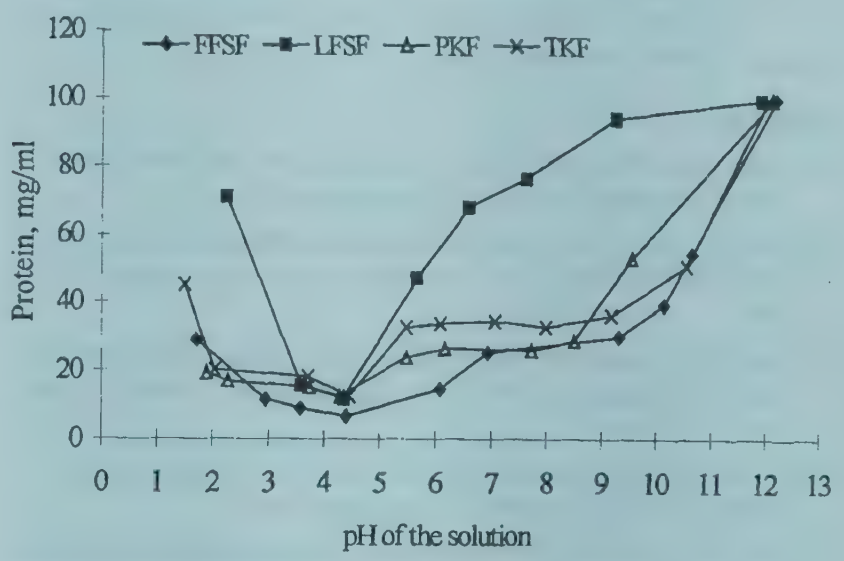

Fig. 2. Solubility profile of proteins at different pHs

nitrogen solubility index of *kinema* flours was significantly ($P \leq 0.05$) higher in comparison to soyflours. *Bacillus subtilis* is known to produce a number of proteolytic enzymes which hydrolyze protein to smaller peptides and finally ammonia (Priest 1989). These chemicals are responsible for increase in water soluble nitrogen and flavour of *kinema* (Sarkar et al. 1984; Nikkuni et al. 1995).

The lightness value ('L') for the products was significantly ($P \leq 0.05$) different, in decreasing order from FFSF to LFSF, TKF and PKF (Table 2). *Kinema* flours were significantly darker, more reddish ('a') and more yellowish ('b') than soyflours. The dark and brown colours of *kinema* flours, particularly PKF, were probably due to a greater degree of heat treatment during processing, resulting in a Maillard type browning reaction.

The protein solubility profile showed minimum solubility for all four samples at pH 4.0-4.5, the apparent isoelectric pH (pI) range for soy protein (Wolf 1970) (Fig. 2). Compared to soyflours, *kinema* flours seemed to have less change in protein solubility with pH.

Conclusion

Kinema fermentation caused little change in protein, oil, ash and energy value of soybean. Crude fibre and total sugars were reduced accompanied by increase in reducing sugars.

Protein quality improved as indicated by the higher NSI. Water and oil retention capacity, gel forming ability and foaming capacity of *kinema* flours were lower ($P \leq 0.05$) but wettability and emulsifying ability were higher ($P \leq 0.05$) than in soyflours. Free fatty acids in *kinema* flours were very high. *Kinema* flours appears to be a better protein enrichment medium for cereal based foods than soyflours due to their nutritional qualities and functional properties such as emulsifying capacity.

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RESEARCH PAPER

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Development and Testing of a Milled Shea Nut Mixer

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A manually powered beater type mixer was designed, constructed and tested. The mixer was constructed to effectively mix milled shea nut with little effort and at minimal initial capital. It has a conical shape located located inside a hemispherical mixing bowl. It has an output capacity of 120 kg/h and the capacity of the mixing bowl at full load is 20 kg. The product obtained from the mixer was compared with the product from the traditional method. The results of the comparative economics of milled shea mixer indicated that the cost of mixing one tonne of milled shea nuts using the mechanical mixer costs about $ 2.2 (₦ 220) as compared to $ 6.5 (N 650) for manual mixing. Hence, the high cost requirement of mixing milled shea nut through traditional method and the high labour requirement were considerably reduced.

Keywords : Mixing machine, Manual operation, Milled shea nut, Oil extraction, Beater mixer.

Shea butter oil is one of the important derivatives from Shea butter tree (*Vitellaria paradoxia*). The plant grows in the wild and widely distributed around the Svannah region of Nigeria. Shea butter oil is obtained from the nut of the plant. The extraction of shea butter oil is on small-scale production level. The oil is processed by traditional method with little mechanical assistance. Shea butter oil is considered as a close substitute for oil palm in some part of Northern Nigeria (Olaoye 1990). It is used for soap making, pomade, medicinal purpose and as a raw material for industries (Hampton and Fellows 1992). According to Patterson (1989) shea nut contains about 34-45 % fat;. fibre products, carbohydrates and proteins constitute the other components of shea nut. Chemical analyses of shea butter oil also revealed that the oil contained FFA, saponification value, Iodine value, unsaponifiable matter, peroxide value and ash content value corresponding to 2.16, 177.0, 59, 6.5 %, 2.6 and 0.16, respectively (Fernando and Akajobi 1987). It is more saturated than cocoa butter and it is used as cocoa substitute. Shea butter has dual characteristics, a fat at ambient temperature (25-30°C) and oil at temperature above this value (UNIFEM 1993).

According to UNIFEM (1993), shea butter nut processing provides approximately 60 % of the income for women in the Sahel and is a vital source of fat for the community. Niess (1983) developed a dry extraction method for shea butter. This method reduced the arduous task involved in traditional procedure and improved the oil output. But this method could bring about a change in the traditional division of labour, affecting the earnings of the women. In Nigeria, application of mechanical devices such as hydraulic or screw press for removal of oil are rarely used. The steps involved in the traditional processing of shea butter oil are presented in Fig. 1.

Traditional mixing takes place in a large pot, strong enough to withstand the applied force through trampling that causes mixing or stirring of the milled shea nut. According to Olaoye (1994) mixing of milled shea nut with water caused the colour of the milled shea nut to change from brownish to

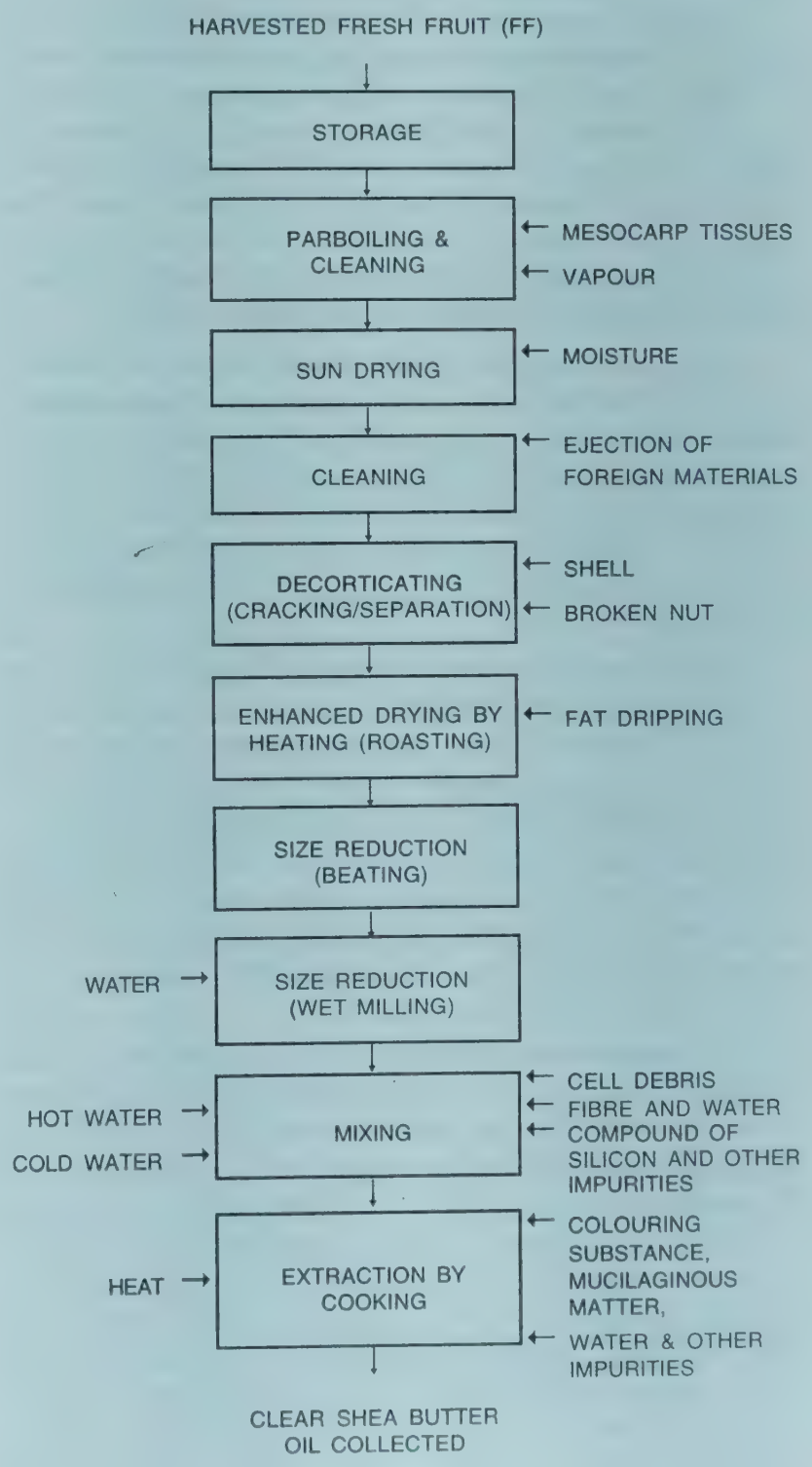

Fig. 1. Flow chart for the local processing of shea butter oil

**Corresponding Author*

greyish colour and the resulting dillution enhanced easy separation of oil and precipitation of the impurity and fibres during cooking. There are mechanical devices for drying and size reduction operations, but mixing of milled shea nut is yet to be mechanized. Olaoye (1994) found that the quantity of oil obtained through the traditional method was low, the procedure was time consuming and the mixing operation was a difficult task. Mainly, women carry out the processing of shea butter with the assistance of children.

This study was aimed at mechanizing the indigenous method of mixing of milled shea butter during traditional processing of shea butter oil. For this purpose, a mechanical mixer was designed, tested and compared with the traditional trampling of mixing procedure.

Materials and Methods

Design of the mixer : McCabe et al (1985) described two methods of operation of Change Can mixers as pony mixer and beater mixer. The milled shea nut is a viscous material. A Change Can mixer mixes viscous liquid or light pastes. It consists of a small removable can, which holds the material to be mixed. The motion of the beater or agitator causes the redistribution of material components. The beater or agitator covers the entire portion of the mixing bowl. The milled shea nut mixer under consideration is the beater type.

The requirement for effective mixing of viscous material is to ensure that all materials must be brought to the agitator/ beater or the agitator must visit all parts of the mix. As the beater rotates, it compresses the mass of the material, so that it repeatedly visits all parts of the vessel (McCabe et al. 1985). The beater creates a flow pattern in the system, causing the liquid to circulate through the vessel and return eventually to the beater.

Fig. 2 shows the general design of the mixer. A close clearance was provided between the sides and bottom of the mixing bowl and the beater during operation. The operation of the beater was to generate both rotary and translatory motion for effective mixing of the milled shea nut. A planetary gear assembly was used to generate a planetary motion of the beater from the effort applied to the handle. The whole arrangement was mounted on a wooden support. The basic design considerations for the milled shea nut mixer are summarized as follows.

(i) Capacity of the mixing bowl is fixed to ensure a mixing time of 10 min for 20 kg of Milled Shea Nut (MSN). (ii). Low labour requirement and an expected input power that can be supplied by children or women is assumed to be 0.25 kW and an average man can supply 0.25-0.30 kW continuously for 6-8 h, including rest time for relaxation and refreshment (Gosh 1978; Inns 1992). (iii.) A hemispherical mixing bowl is given. The tank bottom is rounded to eliminate sharp corners or region into which the fluid materials would be locked. (iv.) A conical shape beater is chosen. The beater is shaped to pass with close clearance over the side and bottom of the mixing vessel (McCabe et al. 1985; Lindley 1991), (Fig. 2). (v.) A shaft driven by a handle connects a planetary gear assembly to the beater thus allowing two motions of the beater rotating

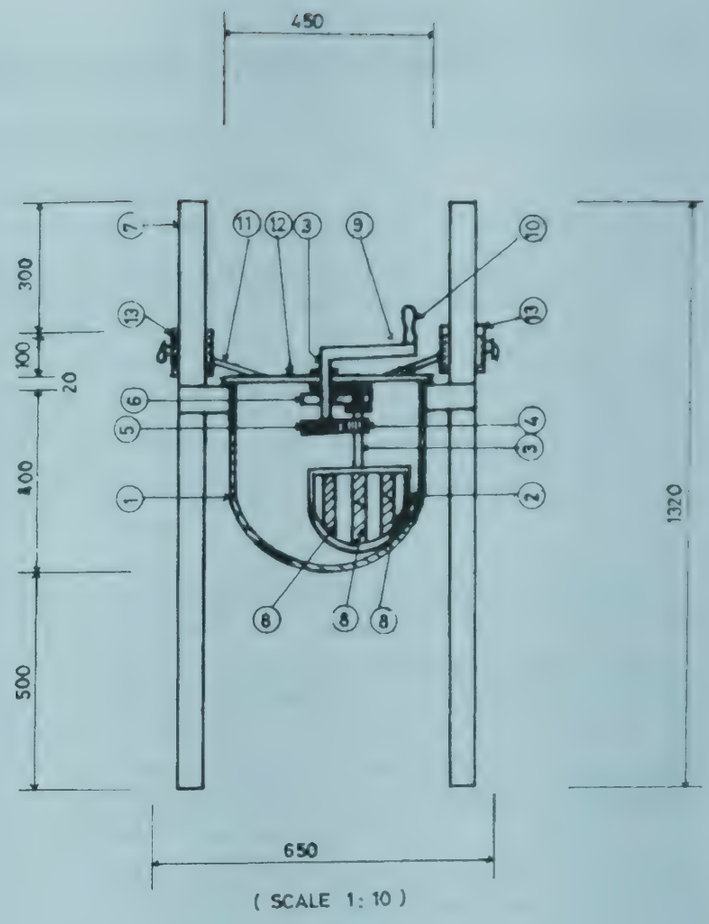

Fig. 2. Sectional view of the milled shea nut mixer
1. mixing bowl 2. beater 3. shaft 4. planet gear 5. sun gear 6. arm 7. main frame 8. paddle 9. cranke 10. handle 11. beater holder 12. corner plate 13. sliding guide

around the bowl and on the axis. A planetary motion of beater is desired for effective mixing of viscous material (Novak and Rieger 1969), (Fig. 2) and (vi.) The basic parameters of the milled shea nut (MSN) mixer are velocity of the beater, time of mixing, and diameter of the beater. The power delivered to the fluid during mixing depends on these parameters. The mixing time and the power requirement are functions of the speed; physical properties of the fluid and its characteristic properties related to power and Reynolds numbers. These variables are : density of the MSN is 1.082 g/cm^3 and for standard, 6- bladed beater, power number, Np is 5.2 (McCabe et al. 1985 ; Hall and Godfery 1968).

Development : The milled shea nut-mixing machine developed is a vertical feed, manually operated unit. The various components of the mixer are frame assembly, conical shaped anchored beater with three blades, mixing beater shaft, planetary gear assembly, shaft handle and the hemispherical mixing bowl that is supported with a wooden stand.

Geometry of mixing bowl : A hemispherical vessel was considered to accommodate the beater. The capacity of the vessel, V_b is calculated using equation 1 as

$$V_b = \frac{M_{sn}}{\rho} \quad (1)$$

18500 cm^3 with Mass of Milled shea nut, M_{sn} = 20000g and density of milled shea nut, ρ= 1.082 g/cm^3. The capacity of the mixing machine, M_{ca} was expressed in equation 2 as the capacity of the mixing bowl per time taken for mixing. It is obtained as 110.8 1/h, where V_b is obtained from equation 1 and time taken for mixing, t_m = 0.167 h.

$$M_{ca} = \frac{V_b}{t_m} \quad \text{..... (2)}$$

The diameter of the mixing bowl, d_m was obtained from equation 3 (McCabe et al. 1985)

$$d_m = \left(\frac{24V_b}{2\pi}\right)^{1/3} \quad \text{..... (3)}$$

as 41.0 using V_b as obtained from equation 1. All parameters in equations 1—3 are as defined in the notation.

Mixing velocity of beater : The beater created flow pattern in the system causing the fluid to circulate through the vessel and return evenly to the beater. The power requirement, P was assumed to be 0.25 kW, diameter of the beater, and d_b to cause mixing were 0.195 m and 0.92 m/s, as the speed of mixing, V_s for hand operation of the beater. The mixing velocity of the beater and the gear ratio of the planetary assembly was obtained from the expression for the mixing speed, power input, P_o and speed of rotation, N of the beater using equations 4 and 5 (McCabe et al. 1985; Faires 1965). Factor of safety of 1.2 was used in equation 4. Therefore, speed of beater, N is calculated as 115 rpm and the speed of mixing, V_s 1.00 m/s.

$$V_s = \frac{\pi d_b N}{60} \quad \text{..... (4)}$$

$$P = \frac{N\rho N^3 D^5{}_b \rho}{g_c} \quad \text{..... (5)}$$

The input speed, N of the revolution of handle at 115 rpm gave the angular speed, ω of the planet gear from equation 6 as 5.1 rad/s. About 90 % of the input speed was assumed to be transmitted to the beater and the number of teeth of the sun was 30.

$$V = \omega r \quad \text{..... (6)}$$

Therefore, it was assumed that gear 1: the sun was fixed with the same angular velocity of gear 2, the planet and arm 3 relative to ground. The number of teeth of the planet gear were obtained as 18 teeth from Marbie and Reinholtz (1987) as shown in equation 7 since, the sun and the planet moved in opposite direction. All parameters in equations 4-6 are as defined in the notation.

$$\omega_{21} = \omega_{31}\left(1 \frac{N_1}{N_2}\right) \quad \text{..... (7)}$$

Beater mounting shaft : In the mixing machine, when the beater and shaft were loaded with the milled shea nut, the shaft was subjected torque and bending moment is neglected as the shaft was mounted vertically. The torsional Equations 8, 9 and 10 (Faires 1965) were used to calculate the size of the shaft. Torque, T was calculated as 140 kgcm using equation 9, where power input, P_o = 0.25 kW, mechanical efficiency of transmission of power, η =90 % and speed of beater, N = 115 rpm (from equation 5).

$$\frac{T}{J} = \frac{F_s}{r} \quad \text{..... (8)}$$

$$P_o = \frac{2\ \pi\ NT}{4500\eta} \quad \text{..... (9)}$$

Equation 10 was obtained by re expressing polar moment of inertial, J and radius of the shaft, r in equation 8 in term of the diameter of the shaft, d_s. From equation 10 d_s was calculated as 12.3 mm, where, T= 140 kg cm (from equation 9) and torsional shear stress of mild steel, F_s = 375 kg/cm^2 (Marbie and Reinholts 1987).

$$d_s = \left(\frac{16T}{\pi F_s}\right)^{1/3} \quad \text{..... (10)}$$

All parameters in equations 7-10 are as defined in the notation. Based on the available material, a shaft of 20 mm diamter was selected.

Construction of the mixer

Frame : The frame was made of square mahogany wood of size 50 x 50 mm. The overall dimensions of frame were 595 mm x 595 mm x 900 mm high. The mixing vessel was positioned on top of the frame, through a circular hole of 450 mm diamter. In this frame, the support for adjustment of beater was located above the surface of mixing vessel, 400 mm high. This was essential for the sliding and adjustment of the beater in the mixing bowl and for the loading and discharging of the shea nut.

Mixing beater shaft : A mild steel shaft of 25 mm diameter of length 250 mm was used to connect the beater to the planet gear. The crank was made of a mild steel hollow pipe of 45 mm diameter of length 200 mm. It was connected to the fixed axis of rotation arm and the planet gear. The arm connected the plant gear to the sun gear at moving axis of rotation of the sun. The arrangement of the planetary gear assembly is shown in Fig. 2. The handles transmitted the input power through the gear assembly to the anchored beater that rotated inside the hemispherical mixing bowl.

Three blades of a pair of length 150 mm and a length 200 mm, each of width 35 mm and thickness 3 mm, made of stainless steel were placed in a hemispherical anchor of diameter 195 mm. The blades were rigidly welded in place at equidistant. Two mild steel shafts each of 250 mm x 20 mm diameter were fixed to the sliding guide of the frame as a support for adjustment of the beater. These members were used to support the beater inside the mixing bowl.

Mixing vessel : A hemispherical mixing bowl of diameter 400 mm was used. A flat mild steel of thickness 3.5 mm was used. The vessel accommodates the milled shea nut and the

TABLE 1. THE RESULT OF THE PERFORMANCE TEST OF THE MIXER

Input speed	Time of operation, h				Capacity, 1/h				Oil recovery, %				Average oil recovery efficiency, %
(Rpm)	R_1	R_2	R_3	Avg	R_1	R_2	R_3	Avg	R_1	R_2	R_3	Avg	
85	0.185	0.180	0.190	0.185	100	103	96	100	34	32	35	34	85
100	0.168	0.172	0.165	0.168	114	108	112	111	32	30	30	31	77
115	0.150	0.160	0.160	0.157	116	116	116	118	28	30	29	29	72

beater, which freely rotated and compressed so as to be able to visit all parts of the mixing vessel.

Evaluation : The performance of the milled shea nut mixer was evaluated for the mixing period, capacity and oil recovery with respect to the speed of the beater. The unit was run at different speeds by considering the operating speed of the machine when three different people; a boy, a woman and a man operated the machine. The boy, woman and man operated the machine at 85 rpm, 100 rpm and 115 rpm, respectively. To ensure steady speed an operator's mate helped by counting the number of revolutions within a minute of stopwatch. Sample of milled shea nut was collected after passing through the processing stages as indicated in Fig. 1 for the purpose of the testing. The mixing period was established as the time taken, when mixed milled shea nut was assessed to have attained the necessary textural and colour requirements. The capacity of the mixer for various speeds of the beater was determined using equation 2. The oil recovery was estimated as the percentage of the oil recovered from the mixed milled shea nut after extraction.

Results and Discussion

Effect of beater speed on mixing period, capacity and oil recovery : The effect of the beater speed on the mixing period of milled shea nut, the capacity of mixer and the oil recovery of the mixer are presented in Table 1. In the speed range of 85 and 115 rpm of the beater of diameter 19.5 cm, the mixing time decreased between the average time of 0.185 h and 0.160 h as the speed increased. This might be due to the fact that at higher speed the rate at which energy expanded was higher (equation 2). Between the speeds 85 and 115 rpm, the decrease in the mixing time was in the range of 1.5 %. The capacity increased with increase in speed in the speed range of 85 to 115 rpm. The capacity was greater for higher speed.

The percentage oil recovery was greater for lower speed. Increased speed leads to decrease in oil recovery. The increment in the oil yield as speed decreases may be due to the longer time taken for the beater to act on the cell wall of the milled shea nut that entrapped the oil droplet. The effect of longer time enhanced the settling of the heavier particles, hence improved oil yield during cooking. The oil recovery ranged from 34 to 29 % as the speed changed between 85 and 115 rpm.

The oil recovery efficiency of the manual procedure and the mechanical mixer was compared. The average oil content of shea nut was about 40 % (UNIFEM 1993; TPI 1971). The average oil recovery efficiency for the mechanical mixer operated at different speeds is presented in Table 1. The comparative economics of the milled she nut mixer indicated that the mechanical mixer had higher average oil recovery efficiency as compared to manual mixer (Table 2).

Economics of the mixer : The economics of the mixer was worked out and compared with the traditional mixing method and cost of mixing per tonne of milled shea nut (Table 2). The following assumptions were made while calculating the economics of the mixer.

Interest rate on investment, 21 %

Annual repairs and maintenance, 10 % on the investment cost.

No. of working hours/year, 1040 h/y for the mixer and 2080 h/y for traditional method.

Capacity, 120 kg/h for mixer and 40 kg/h for traditional method

Labour cost $ 0.25/ h (₦ 25/h).

The cost of mixing was much less for the developed mixer compared to traditional methods.

Conclusion

A hand operated milled shea nut mixer was developed from the available local materials and it was sufficiently rugged for local production, operation and maintenance. The capacity of the machine was 120 kg/h. The performance of the machine

TABLE 2. COMPARATIVE ECONOMICS OF MILLED SHEA MIXER*

Description	Mechanical mixer, $	Manual mixing, $
Cost of machine	35	1
Annual fixed cost		
1. Interest on investment	7.35	-
2. Depreciation (life period of 10 years)	3.15	-
3. Repair and maintenance	3.50	-
Total annual fixed cost	14.00	-
Fixed cost/h	0.014	
Operating cost/h (wages to labour/h)	0.25	0.25
Total operating cost/h	0.25	0.25
Total mixing cost/h (Fixed cost + operating cost)	0.26	0.25
Hence cost of mixing for one tonne of milled shea nut.	2.20	6.25
Oil recovery efficiency	76 %	72 %

*₦ 100 = US $ 1

was evaluated at beater speed between 85 and 115 rpm. The oil recovery ranged from 29 to 34 %, necessitating selection of a suitable mixing speed in order to optimize the performance of the machine. The cost of mixing is less than the conventional method of mixing.

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Notations

d_b - diameter of beater, mm

d_m - diameter of mixing bowl, mm

d_s - diameter of shaft, mm

F_s - Torsional shear stress of mild steel, 375 kg/cm^2 (Marbie and Reinholtz 1987)

g_c - gravitational contant (9.80 m/s^2)

J - Polar moment of intertia cm^4

M_{ca} - Capacity of mixer (kg/h, 1/h)

M_{sn} - Mass of milled shea nut (kg)

N - Speed of beater (rpm)

N_1 - Number of teeth of sun gear

N_2 - Number of teeth of planet gear

N_p - Power number of beater, 5.2 (MaCable et al. 1985)

P, P_o - Power input (kW)

r - radius of shaft (mm)

T - Torque applied (kg m)

t_m - mixing time (h)

V_b - Volume of mixing bowl (cm^2)

V_s - Speed of mixing (m/s)

ρ - density of milled shea nut (g/cm^3)

η - mechanical efficiency

ω - angular speed (rad s^{-1})

ω_{21} - angular speed of planet relative to sun (rad s^{-1})

ω_{31} - angular speed of arm relative to sun (rad s^{-1})

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RESEARCH PAPER

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Biscuit Making Quality of Advance Lines of Wheat in India

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Sixty wheat grain varieties comprising of advanced breeding lines and released varieties as checks were evaluated for several of the physico-chemical parameters and biscuit making properties. The t-test analysis of samples at two locations showed the significant environmental influence on test weight ($p < 0.001$), protein content ($p < 0.001$), alkaline water retention capacity ($p < 0.001$) and sedimentation value ($p < 0.01$) but non-significant on grain hardness and biscuit diameter. The protein contents varied from 10.5 to 14.5% and showed no correlation with biscuit diameter and spread factor. The sedimentation values ranged from 28 to 67 ml with an average value of 41 ml and displayed no correlation with baking test. AWRC exhibited higher values (70-120) and revealed high negative correlation ($r = -0.68$ and -0.40, $P < 0.01$) with biscuit diameter and spread factor, respectively.

Keywords : Biscuit, Alkaline water retention capacity, Sedimentation value, Protein content, Wheat quality.

India is the second largest producer of wheat in the world. The whole wheat flour in India is used to prepare the flat bread called *chapati,* the staple diet for a very large segment of the population. Recently, the demand for diverse end-use products as bread, biscuit, noodles, cakes and pasta products has increased tremendously (Misra et al. 1998). Biscuit industry is the largest constituent of food processing industry. Since *chapati* has been the staple diet, the emphasis has been for the development of wheat varieties suitable for this purpose. As a result the performance of wheat in India towards bakery products has been found comparatively poor because each product has its own specific requirement. Therefore, it has become necessary to have the information on the performance of Indian wheat on biscuit making quality and also to identify lacuna for improvement. Biscuit diameter and spread factor are the important parameters used for evaluating the wheat varieties for biscuit making quality (Nemeth et al. 1994). Larger biscuit diameter and higher spread factor are considered as the desirable quality attributes (Yamamoto et al. 1996). Generally, wheat flours with low protein content and weak gluten strength (Finney et al. 1987; Souza et al. 1994; Hou et al. 1996 a, b) have been found to have good biscuit (cookie) making quality. In the present paper, an attempt has been made to understand the status of biscuit making quality of advance lines of wheat in India. Further, the study was conducted to identify relationship between some of the physico-chemical components and biscuit making quality including the influence of environment on this property. The results were examined by statistical correlation to determine which tests were correlated with baking performance. This will accentuate breeding efforts producing wheat varieties suitable for biscuit making.

Materials and Methods

Grains from sixty advanced lines including released varieties as checks were cleaned and milled using Buhler Laboratory Mill (MLU202) having pneumatic conveyors and the capacity of 100 g/min (Black et al. 1983). The samples were taken from seven locations representing five zones (North Western Plains Zone (NWPZ), Northern Hill Zone (NHZ), North Eastern Plains Zone (NEPZ), Central Zone (CZ) and Peninsular Zone (PZ) of the country. Each sample had four replicates and all the replicates were used in the measurement of protein content, hectoliter weight and sedimentation value. Baking and alkaline water retention capacity tests were conducted in bulk samples (all the replicates of each line at one location were mixed).

High molecular weight (HMW) glutenins were determined by SDS-PAGE according to the modified method of Ng and Bushuk (1987). Protein content was determined using NIR, Model Tecator-1555. Hectoliter weight was estimated by SINARGP Auto-6080 Test Weight instrument. Wheat grain hardness was determined using hardness tester, model OSK 8055 OGAWA Sciki Co. ltd, Japan. Alkaline Water Retention Capacity (AWRC) was determined according to AACC (1995) Method 56-10. SDS sedimentation values were determined according to AACC (1995) Method 56-70 with minor modifications. The biscuit quality was evaluated by measuring the spread of two sugar-snap cookies (biscuits) baked from 40 g flour as per AACC (1995) method.

Results and Discussion

Sixty lines from various centers representing 5 zones of the country were tested for various rheological, physical and chemical parameters and biscuit making quality. The data shown in Tables 1 and 2 are of advanced lines from two centers namely Durgapura and Pantnagar in North Western Plains Zone in India. Varietal purity was tested using SDS-PAGE of grain samples. All the samples were found to be homogeneous.

Biscuit quality : Larger biscuit diameter and higher spread factor are considered as the desirable quality attributes (Yamamoto et al. 1996). The cookie diameter ranged from 6.44 cm (HI1479) in Kota to 7.10 cm (RW3494) in Pantnagar. Most of the lines were having lower diameter (Fig. 1). The spread factor was even lesser and varied from 5.28 (HI1479) to 6.64 (RW3494). Majority of the advanced lines showed spread factor less than 6 (Fig. 2). This indicates that there is a tremendous scope for the improvement of biscuit making quality. The t-test analysis of samples at two locations showed that there was no significant environmental influence on biscuit diameter. Generally, low protein content, weak gluten strength and softer wheat grain have been specified for good cookie making quality

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TABLE 1. TEST WEIGHT, PROTEIN CONTENT SEDIMENTATION VALUE (SED. VALUE), AWRC, GRAIN HARDNESS, BISCUIT DIAMETER (W), THICKNESS (T) AND SPREAD FACTOR (W/T) OF 13 WHEAT LINES FROM DURGAPURA (NWPZ) (1998-99)

Variety	Test wt., kg/hl	Protein content, %	Sed. value, ml	AWRC value, %	Grain hard-ness, kg	Width (W), cm	Thick-ness (T) cm	Spread factor W/T
'PBW-443'	77.7	12.7	41	98	11.8	6.82	1.12	6.1
'HD-2329'	77.3	12.5	39	103	11.5	6.70	1.18	5.7
'WH-542'	74.4	13.2	50	100	10.3	6.75	1.20	5.6
'UP-2338'	75.2	13.4	37	99	9.7	6.75	1.17	5.8
'PBW-343'	75.4	13.3	41	99	9.3	6.74	1.17	5.8
'HD-2687'	72.3	13.0	40	103	11.4	6.77	1.17	5.8
'PBW-459'	75.4	14.5	42	94	11.2	6.90	1.18	5.8
'PBW-465'	76.0	12.8	35	97	11.7	6.81	1.13	6.0
'PBW-466'	76.6	13.1	48	103	12.1	6.80	1.15	5.9
'UP-2481'	76.1	13.2	40	100	11.9	6.76	1.18	5.7
'WH-712'	72.4	13.6	67	102	12.5	6.67	1.22	5.5
'HUW-520'	76.3	13.5	46	99	10.2	6.69	1.20	5.6
'RW-3494'	77.2	14.4	45	83	9.3	7.05	1.12	6.3
Mean	75.6	13.3	44	98	11.0	6.79	1.17	5.8
SD	1.63	0.57	7.82	5.12	1.05	0.12	0.03	0.23

TABLE 2. TEST WEIGHT, PROTEIN CONTENT SEDIMENTATION VALUE (SED. VALUE), AWRC, GRAIN HARDNESS, BISCUIT DIAMETER (W), THICKNESS (T) AND SPREAD FACTOR (W/T) OF 13 WHEAT LINES FROM PANTNAGAR (NWPZ) (1998-99)

Variety	Test wt., kg/hl	Protein content, %	Sed. value, ml	AWRC value, %	Grain hard-ness, kg	Width (W), cm	Thick-ness (T) cm	Spread factor W/T
'PBW-443'	80.8	11.4	36	85	12.4	6.84	1.20	5.7
'HD-2329'	79.9	12.0	37	82	12.7	6.73	1.18	5.7
'WH-542'	78.8	10.5	32	90	10.1	6.71	1.18	5.7
'UP-2338'	79.4	11.0	33	93	11.0	6.80	1.35	5.4
'PBW-343'	78.8	10.9	29	89	9.8	6.72	1.22	5.5
'HD-2687'	77.7	10.8	37	86	9.7	6.70	1.20	5.6
'PBW-459'	81.0	11.0	37	86	11.0	6.72	1.27	5.3
'PBW-465'	79.5	11.8	28	80	12.1	6.79	1.10	6.2
'PBW-466'	77.9	11.7	41	74	9.5	6.75	1.22	5.5
'UP-2481'	76.3	11.2	32	86	10.0	6.73	1.22	5.5
'WH-712'	79.8	11.4	58	83	10.1	6.86	1.17	5.9
'HUW-520'	80.6	11.4	30	80	9.1	6.81	1.17	5.8
'RW-3494'	79.2	10.9	45	70	9.1	7.10	1.07	6.6
Mean	79.2	10.4	37	83	10.5	6.79	1.19	5.7
SD	1.28	4.61	7.74	6.09	1.18	0.10	0.07	0.34

(Hoseney et al. 1988; Gaines and Finney 1989; Souza et al. 1994; Hou et al. 1996 a, b). The possible reasons for low biscuit diameter and spread factor of advanced wheat lines have been discussed below.

Protein quality and quantity : Wheat grain protein content varied from 10.5 to 14.5% (Fig. 3) depending upon the variety and the location. Because wheat cultivars studied here were taken from vastly growing regions, the effect of the environment

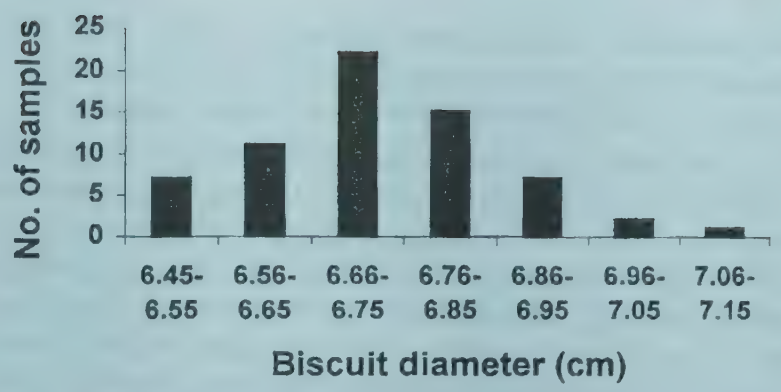

Fig. 1. Bar diagram of biscuit diameter of 60 wheat lines grown at different locations in 1998-99

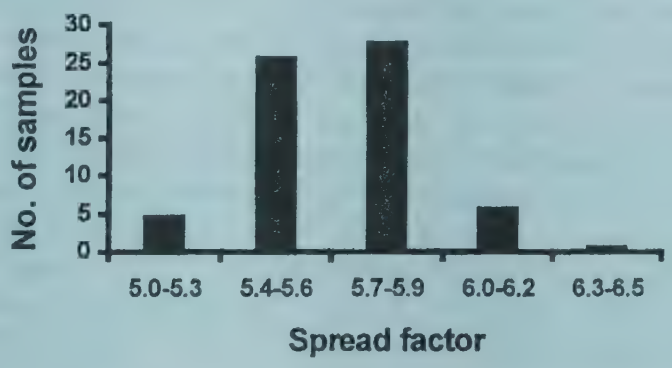

Fig. 2. Bar diagram of spread factor of 60 wheat lines grown at different locations in 1998-99

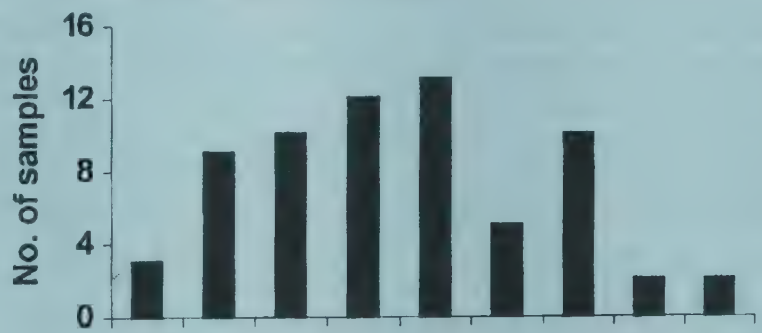

Fig. 3. Bar diagram of protein content of 60 wheat lines grown at different locations in 1998-99

is not clear. However, similar set of samples was used from Durgapura and Pantnagar, the t-test analysis of these samples indicated significant influence of the environment on protein content ($p < 0.001$). An earlier study also identified centers having high and low protein content representing all the zones in the country (Misra et al. 1998). Grain protein content did not correlate significantly ($r^2 = 0.02$ and 0.06) with biscuit diameter and spread factor, respectively. This might be due to higher levels (>10.5%) of grain protein content in these samples. Further, it may be because of diverse genetic background differing in LMW-GS and gliadin subgroup composition and sub-unit quantity (Bushuk 1998). Earlier reports indicated the relationship between individual protein sub-units and dough properties (Payne et al. 1987; Gupta and MacRitchie 1994; Hou et al. 1996 a, b). Glu-1 score was found negatively correlated with British biscuit making quality (Payne et al. 1987). Hou et al (1996 b) reported positive correlation between sub-unit 1 and biscuit diameter. There may be difference in molecular weight distribution of glutenins determining physical dough properties

as reported by Southan and MacRitchie (1999). Work is in progress to ascertain the role of individual protein sub-units and molecular weight distribution in biscuit making quality.

Sedimentation value : Sedimentation value reflects the proportion of glutenin and gel protein (Moonen et al. 1982), the major determinant of end-product quality. The sediment in the SDS solution theoretically results from the swelling of glutenin strands and high sedimentation values have been associated with stronger gluten and superior bread making quality (Axford et al. 1979; Lorenzo and Kronstad 1987; Ayoub et al. 1983). Carter et al (1999) have shown relationship between SDS sedimentation taking into account the protein content with soft white wheat end-product quality. In the present study, the sedimentation values varied from 20 to 70 ml with the average value of 41 ml (Fig. 4). The t-test analysis of samples at two locations showed that the environment had significant influence ($p < 0.01$) on the property. The values were significantly higher in Durgapura as compared to Pantnagar and the cultivar 'RW-3494' had stable sedimentation value across the environments (Tables 1 and 2). The correlation between sedimentation value and biscuit diameter could not be established.

Alkaline Water Retention Capacity (AWRC) : AWRC is used extensively in US but it is not considered as highly significant in the Canadian soft wheat testing programme (Bushuk et al. 1998). A negative correlation ($r = -0.70$ to -0.85) between AWRC value and the spread of cookie made with straight grade flour was reported by Hoseney et al (1988). Recently adverse effect of 1B/1R translocation on baking quality of soft red winter wheat has been attributed to higher AWRC value (Johnson et al. 1999; McKendry et al. 1996). AWRC varied from 70 to 120 (Fig. 5) in all the zones in the country and was unusually higher than reported in good biscuit making quality varieties else where in the world. It showed a significant negative correlation with both biscuit diameter ($r = -0.68$, $p < 0.01$) and spread factor ($r = -0.40$, $p < 0.01$). The multiple regression analysis was done to find out the contribution of various parameters in Tables 1 and 2 towards biscuit diameter. It showed that AWRC contributed about 98% of the multiple r^2 value of 0.8521 in Durgapura and 96% of the multiple r^2 value of 0.6363 in Pantnagar. But the regression analysis between AWRC and biscuit diameter using sixty lines from different parts of the country showed that r^2 value was 0.246 (Fig. 5). This may be because majority of values of AWRC concentrated between 90-100. The t-test analysis showed significant influence of the environment on AWRC ($p < 0.001$). The varieties in peninsular zone displayed higher AWRC and lower biscuit diameter. Since wheat varieties have been developed for *chapati* quality which requires higher water absorption and medium gluten strength, it is not yet clear if the higher water absorption genetically controlled or is a consequence of environmental effect. The higher AWRC value may be due to higher soluble protein content, harder grain texture and accumulation of pentosans (Bettge and Morris 2000). Harder grain texture cause higher starch damage that is detrimental to the biscuit quality (Nemeth et al. 1994; Yamamotto et al. 1996). Molecular and rheological studies are being conducted to further elucidate the reasons for

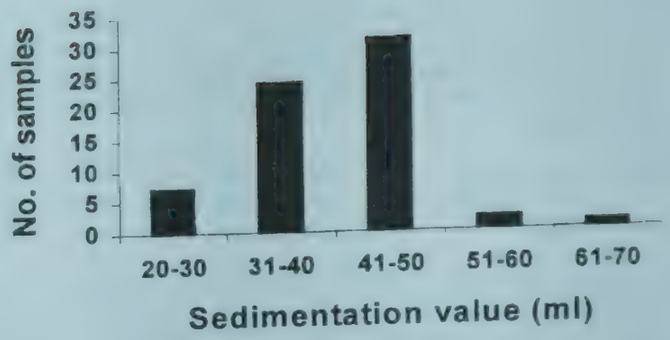

Fig. 4. Bar diagram of sedimentation value of 60 wheat lines grown at different locations in 1998-99

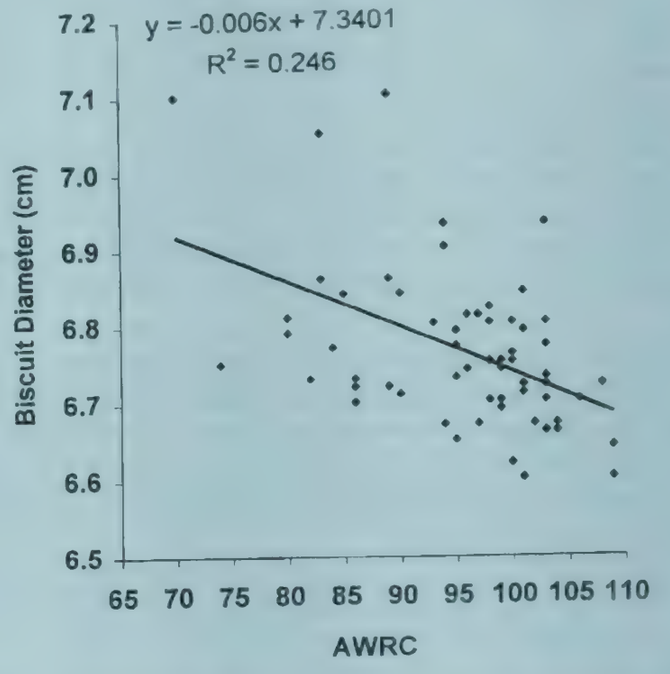

Fig. 5. Relationship between AWRC and biscuit diameter for 60 wheat lines grown at different locations in 1998-99

poor performance of wheat for biscuit making quality and work out strategies to improve it further. For this purpose a large germplasm is being screened and interesting material has been found for usage in the breeding programme for the improvement of wheat for biscuit quality.

It may be concluded that the value of AWRC was in higher range and exhibited high negative correlation with cookie diameter and spread factor. The reasons for higher AWRC are to be identified. The protein content and sedimentation value did not exhibit relationship with cookie diameter and spread factor. The role of individual protein subunits and molecular weight distribution in cookie making quality are yet to be ascertained. Such an attempt will help the breeding programme in improving the biscuit making quality of Indian wheat varieties.

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RESEARCH PAPER

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Development and Nutritional Evaluation of Proso Millet-based Convenience Mix for Infants and Children

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Two convenience mixes suitable for five different types of baby foods based on proso millet *(Panicum miliaceum)* were developed. Malting and popping were used as processing techniques. Malted convenience mix was further used as multipurpose flour for development of different baby foods. These five baby food products were sweet gruel, salty gruel, *halwa*, *burfi* and biscuits. The nutritional quality of mixes was analyzed for moisture, crude proteins, energy and total ash contents of malted and popped convenience mixes. Iron and ascorbic acid contents of malted convenience and popped convenience mix were also determined. The Protein Efficiency Ratio (PER) was assayed with malted convenience mix and popped convenience mix. Values of hot paste viscosity for malted convenience mix, for popped convenience mix and for proprietary mix gruels were observed. Proteins, energy, fat, calcium, ascorbic acid, iron and β-carotene (per 50 g convenience mix) for baby food products were calculated from the values analyzed. The protein content was found to be similar for all food products. Calcium (mg), ascorbic acid (mg), iron (mg) and β-carotene (μg) were found to be similar for all the food products. All the food products were organoleptically acceptable. A non-significant difference at $p = 0.05$ was observed among the scores for five food products developed.

Keywords : Proso millet, Convenience mix, Infants, Malting, Popping.

Millets are small seeded annual cereal grains. These are very hardy crops and can be grown successfully on infertile land. The crops are less prone to diseases and pests in the field and store (ICAR 1987). Millets in India occupy 4-5 percent of the cultivated area and are confined to vast stretches of dryland and hill areas. The nutritive value of millets is comparable to other staple cereals like wheat and rice, some of them are even better with regard to average protein, fat and mineral contents (Gopalan et al. 1997; ICAR 1987). But their utilization is limited mainly to poor section of population of Kumaon hills, cattle and poultry. The reason being presence of anti-nutrients, poor digestibility of protein and carbohydrates and low palatability (Thompson 1984; Pawar and Parlikar 1990; Chitra et al. 1996). The sensory properties are also poor due to coarse nature of these grains. These are rich in polyphenols, which influence the colour and flavour of millet (Rao and Deosthale 1988). The non-availability of refined and processed millet in ready-to-use form has further limited their use and acceptability. Thus, at the present era of food scarcity there exists a need to diversify the use of these millets by developing non-conventional food products, especially for young children among whom protein energy malnutrition is prevalent. Although breast feeding is beneficial for the optimum growth of the children, prolonged breast feeding without appropriate complementary feeding is crucial contributory factor for malnutrition among young children (Huffman and Martin 1994; Gopaldas et al. 1982). Therefore supplementation should be instituted to overcome malnutrition and related infection. Though a number of commercial formulae which provide balance weaning foods are available in the market, these are too expensive and are not within the reach of very poor (Chandrasekhar et al. 1988). Hence, development of weaning and supplementary food based on inexpensive, locally available millets and legumes is an excellent way to combat protein-energy malnutrition among children of Kumaon hills.

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For development of weaning and supplementary foods, certain processing techniques such as popping and malting could be easily adopted at household level and cottage level. Popping is done by roasting the grains in a hot medium (salt or sand). Popped grain is crunchy, porous and precooked product. Popping invariably improves taste and flavour. Popped material has a low bulk density and improved *in vitro* protein digestibility. Popping leads to development of pleasing texture with distinct appealing flavour. Popping formulation has very low moisture. This decreased moisture helps in minimizing deterioration during storage which inturn increases the shelf life of the product (Malleshi and Desikachar 1981). The process of malting allows partial pre-digestion of starch and protein. Malting of grains causes increase in activities of hydrolytic enzymes, improvements in the contents of total proteins, fat, ash, certain amino acids, total sugars and B-group vitamins (Sachdeva and Chaudhary 1994). Decrease in anti nutrients phytate and protease inhibitor are the metabolic effects of sprouting process. The best advantage of malting is that viscosity could be reduced to any desirable level, depending on the extent of germination, making the process especially suitable for very young babies. The decrease in viscosity leads to an increase in nutrient or caloric dense food per unit volume consumed (Chandrasekhar et al. 1988; Gopaldas 1994).

Hence, the present study was taken up to develop proso millet based two convenience mixes for five food products for young children suitable for preparation at household and commercial level.

Materials and Methods

Proso millet *(Panicum miliaceum)*, soybean *(Glycine max.)* and groundnut *(Arachis hypogaea)* were obtained from local market of Haldwani, district Nainital, U.P. Popping of proso millet was done in an iron pan containing salt maintained at 240 to 260°C temperature and stirred briskly for 15-25 sec. Thereafter, the mixture containing salt and popped grains were passed through 20 mesh sieve to separate salt from popped grains.

Malting of proso millet was done by soaking the grains in water (2-3 times more than grain's volume) for 12 h. It was then allowed to sprout for 48 h in an incubator (22 ± 2°C). The sprouted grains were then dried in an air drier (50°C) for 6-8 h and thereafter germinated grains were rubbed by hand to devegetate the sprouts. The sprouts were discarded and toasting of millet was done in a skillet at mild temperature (50-60°C) until characteristic malting flavour developed. Soybean and groundnuts were roasted at 70 to 110°C for 20 min. Then the husk was removed by hand rubbing. All the above ingredients were ground in an electric grinder to pass through 100 mesh sieve.

Preparation of convenience mixes : The convenience mixes were prepared

i. Malted convenience mix was prepared by taking malted proso millet flour (70%), roasted soybean flour (15%) and roasted groundnut flour (15%) and

ii. For popped convenience mix, 70% of popped proso millet flour was taken and rest of the ingredients were same.

Development of food products : The malted convenience mix was further used as multipurpose flour for the development of supplementary foods for infants and young children. Five different food products namely, sweet gruel, salty gruel, *halwa, burfi* and biscuits were prepared from the convenience mix.

Sweet *gruel :* It was prepared by adding 60 ml lukewarm water and 10 g sugar to 50 g of convenience mix.

Salty *gruel :* Various vegetables like brinjal, beans, cauliflower, cabbage etc with salt were cooked in pressure cooker till soft. These were added to 50 g of convenience mix to make a gruel.

Halwa : It was prepared by adding 50 g of convenience mix to boiled water. Sugar (20 g) and ground cardamoms were added to it and cooked.

Burfi : For preparing *burfi,* sugar (20 g) syrup was prepared. To it convenience mix (50 g) was added and cooked. The mixture was then poured in a greased plate and was garnished with roasted amaranth seeds and coconut scrapings. After the mixture was set, it was cut into square pieces.

Biscuits : For preparing biscuits, baking powder, sugar (25 g) and fat (5 g) were added to the convenience mix (50 g). A stiff dough was made with water. The dough was rolled into 1 cm thick chapati and cut into the shape of biscuits. Biscuits were baked in a preheated oven (15 min, 150°C temperature) for 30 min.

Estimation of nutritional quality : The convenience mixes prepared were analyzed for proximate composition, iron, calcium and ascorbic acid according to AACC (1975) methods. Protein, energy, fat, calcium, ascorbic acid, iron and β-carotene content of five food products were estimated on the basis of values analyzed and values given by Gopalan et al (1997).

Determination of Protein Efficiency Ratio (PER) : The protein quality of convenience mixes was evaluated by measuring PER according to Campbell (1963) with slight modifications. The protein level of the diet was adjusted to 10%. Weanling albino mice ten per group were housed in individual cages at

TABLE 1. COMPOSITION OF DIET PER ESTIMATION

Ingredient	Casein diet	Test diet	
		Malted convenience mix	Popped convenience mix
Casein, g	102.00	–	–
Convenience mix, g	–	696.90	625.80
Corn starch, g	748.00	153.10	224.20
Groundnut oil, g	90.00	90.00	90.00
Salt mixture*, g	40.00	40.00	40.00
Vitaminized starch*, g	10.00	10.00	10.00
Vitaminized oil*, g	10.00	10.00	10.00
Total, g	1000	1000	1000

*Prepared according to IS 1974

room temperature (26.5 to 30°C). The experimental diet and control diet was fed to mice *ad libitum* (Table 1). Drinking water was supplied by an individual nipple water bottle attached to each cage. Casein diet was used as control. Weekly gain and food intake of mice were recorded for 4 weeks.

Evaluation of viscosity : Viscosity of malted, popped convenience mix and proprietary mix at 40% slurry concentration was measured by a Brookfield Synchro-electric viscometer according to Brandtzaeg et al (1981). Temperature was maintained at 60-70°C. The viscosity was measured in centipoise (cps).

Evaluation of sensory quality : The five food products developed were evaluated for sensory quality characteristics on a 9-point Hedonic scale to test the liking or dislikings. The evaluation was done by a trained panel of ten members (Amerine et al. 1965).

Statistical analysis : Both the convenience mixes were analyzed for proximate composition, iron and ascorbic acid in three replicates each. One way ANOVA (f-test) was used to find out significant differences between the two convenience mixes for sensory qualities of five baby food products (Snedecor and Cochran 1967).

Results and Discussion

Nutritional quality of convenience mix : The values for proximate composition of popped and malted convenience mixes are given in Table 2. The moisture content of malted convenience mix (6.66%) and popped (6.16%) differed significantly ($p=0.05$). Significant differences were also observed for crude fat, crude protein and physiological energy between malted and popped convenience mix. The values for crude fat (%), crude proteins (%) and physiological energy (kcal) for malted mix were 5.00, 14.35 and 328, respectively and for popped mix were 5.43, 15.98 and 336, respectively. The difference could be attributed to different processing application of proso millet.

Non-significant differences were observed in values of total ash, Neutral Detergent Fibre (NDF) and carbohydrate content between malted and popped convenience mixes. Total ash, NDF and carbohydrate contents were observed to be 2.50, 15.00 and 56.49%, respectively for malted convenience mix

TABLE 2 PROXIMATE COMPOSITION, IRON AND ASCORBIC ACID CONTENTS OF CONVENIENCE MIXES BASED ON MALTED AND POPPED PROSO MILLET

Convenience mix	Moisture, %	Crude proteins, %	Total ash, %	Neutral detergent fibre, %	Crude fat, %	Carbohydrates, %	Physiological energy, kcal	Iron, mg/100 g	Ascorbic acid, mg/100 g
Malted mix	6.66	14.35	2.50	15.00	5.00	56.49	328	4.20	8.86
Popped mix	5.16	15.98	2.45	15.08	5.43	55.90	336	4.10	0
SEM ±	0.17	0.19	0.96	0.11	0.38	0.54	1.63	0.42	0.20
CD at 5%	0.57	0.65	0.33	0.37	0.13	1.87	5.62	0.15	0.69

TABLE 3. NUTRIENT COMPOSITION OF FOOD PRODUCTS PREPARED FROM 50 g OF CONVENIENCE MIX

	Proteins, g	Energy, kcal	Fat, g	Calcium, mg	Ascorbic acid, mg	Iron, mg	β-carotene, µg
Sweet gruel	7.16	244.00	1.25	41.24	4.42	2.10	31.95
Cooked weight - 180 g							
Salty gruel	7.16	127.00	5.00	41.24	4.42	2.10	31.95
Cooked weight - 160 g							
Halwa	7.16	227.00	5.00	41.24	4.42	2.10	31.25
Cooked weight - 128 g							
Burfi	7.16	227.00	5.00	41.24	4.42	2.10	31.95
Cooked weight - 60 g							
Biscuits	7.16	334.00	5.00	41.24	4.42	2.10	31.95
Cooked weight - 98 g							

and 2.45, 15.08 and 55.90%, respectively for popped convenience mix. Iron (mg/100 g) and ascorbic acid (mg/100 g) for malted convenience mix were 4.20 and 8.86, respectively and for popped convenience mix 4.10 and 0, respectively (Table 2). Non-significant difference was observed for iron content. The significantly higher content of ascorbic acid in malted convenience mix is attributed to enzymatic hydrolysis of starch by amylases and diastases which produce mixture of glucose, maltose and small amount of dextrin. The increased amount of glucose becomes precursor for ascorbic acid (Taur et al. 1984).

Nutrient composition of food products : Nutrient composition of the food products sweet gruel, salty gruel, *halwa, burfi* and biscuits developed from malted convenience mix is shown in Table 3. The energy content (kcal) of sweet gruel, salty gruel; *halwa, burfi* and biscuits prepared from 50 g convenience mix was observed to be 244, 127, 227, 227 and 334, respectively. The protein content of all the five food products developed, namely, sweet gruel, salty gruel, *halwa, burfi* and biscuits were found to be similar, i.e. 7.16 g per 50 g mix. Calcium (mg), ascorbic acid (mg), iron (mg) and β-carotene (µg) contents per 50 g mix for sweet gruel, salty gruel, *halwa, burfi* and biscuits were 41.24, 4.42, 2.10 and 31.95, respectively. Sweet gruel and salty gruel were the two products developed for infants. The breast milk can alone meet the nutrient requirement of the child up to 4-6 months of age. Thereafter the child's need for energy and protein increases for growth and regulation of various body functions. An infant aged 6 months to 1 year requires about 14 g protein and 843 kcal of energy daily (Gopalan et al. 1997). Breast milk that may be available to them may provide approximately 5 g of proteins and 300 kcal energy (NIN 1977). As a result, rest of the energy and protein should be fulfilled by supplementary food

As earlier stated sweet gruel and salty gruel provide 244 kcal and 127 kcal of energy, respectively and 7.16 g of protein per 50 g mix. Considering the frequency of consumption two times a day, the sweet gruel alone can fulfil the protein and energy requirements of an infant. Similarly, if salty gruel is consumed four times a day, it can also meet the energy and protein requirements of infant.

For young children *halwa, burfi* and biscuits were developed. A young child aged 1-3 years requires about 240 kcal of energy and 22 g protein per day (Gopalan et al. 1997). *Halwa* and *burfi* prepared from 50 g convenience mix can fulfil one fifth of energy requirement and one third of protein requirement daily and biscuits can fulfil one fourth of daily energy requirement and one third of daily protein requirement. These food products can serve as nutritious snack items for children in order to fulfil their daily requirements for protein and energy.

PER of convenience mix : A Protein Efficiency Ratio (PER) of 2.13 was observed for malted convenience mix and 1.88 for popped convenience mix against casein standard for which a value of 2.50 was observed. A significantly higher value of PER for malted convenience mix was observed as compared to popped convenience mix. Average PER of 0.85 to 1.02 has been reported for native millets and 1.00 to 1.05 for kilned malt millets suggesting improvement in average PER on malting (Malleshi and Desikachar 1986). Comparatively higher values of PER observed for malted and popped convenience mixes are attributed to combination of millet, legumes and nuts resulting in better combination of amino acids (Roman et al. 1987; Bressani and Elias 1983).

Viscosity of gruel : Evaluation of hot paste viscosity (60-70°C of the malted convenience mix, popped convenience mix and proprietary mix at 40% slurry concentration revealed significant differences in values ($p = 0.05$). A lowest viscosity

TABLE 4. SENSORY QUALITY OF FOOD PRODUCTS PREPARED FROM CONVENIENCE MIXES

Food product	Score	Rating
Sweet gruel	7.7	Liked moderately to liked very much
Salty gruel	6.9	Liked slightly to liked moderately
Halwa	7.2	Liked moderately to liked very much
Burfi	6.8	Liked slightly to liked moderately
Biscuits	6.6	Liked slightly to liked moderately
CD at 5%	0.95	

of 28.70 cps was observed for malted convenience mix gruel followed by 860 cps for popped convenience mix gruel and 7400 cps for proprietary gruel. Mosha and Svanberg (1983) suggested a semi-liquid consistency with measured viscosity of 1,000-3,000 cps as most suitable for infant feeding. This indicates that malted convenience mix gruel is the most nutrient dense and both malted and popped gruel are suitable for infants and young children.

Sensory quality : The score and ranking of five food products developed from convenience mix is presented in Table 4. The scores for five food products viz. sweet gruel, salty gruel, *halwa, burfi* and biscuits ranged from 6.6 to 7.7. All the food products were acceptable. A non-significant difference was observed in scores among the five food products developed.

Thus, it can be concluded that proso millet flour can be effectively used in the preparation of nutritious food items for infants and young children after suitable processing.

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Thermal Conductivity Measurement Technique *Vis-a-Vis* Quality of Fruit

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A simple probe for thermal conductivity measurement was developed in-house that was cheap, compact, easy-to-handle, required less time and small amount of sample for measurement. The thermal conductivities of fruits (banana, apple and papaya) were measured. Bananas of three different stages of ripening (unripe, ripe and over ripe) were selected and their conductivities were found to be 0.485, 0.51 and 0.524 W/m°C, respectively. Textures of these samples were determined using a Texturometer, which showed that as the degree of ripening increased, the texture of fruit became soft and the conductivity increased. A correlation between degree of maturity, conductivity and texture of banana was observed and this could be extended to other fruits and vegetables.

Keywords : Thermal conductivity, Probe, Fruit, Ripening and texture.

The heat and mass transfer properties of foods are receiving much attention recently because of their fundamental importance in calculation and modelling of various food processes. The thermal transport properties i.e., thermal conductivity and thermal diffusivity are needed in the quantitative analysis of important thermal processes such as heating, cooking, sterilization, drying and extrusion cooking.

Two broad methods have been used to measure thermal conductivity of food materials, the steady state and the unsteady state methods. The steady state technique (guarded hot plate, concentric cylinder, concentric sphere, etc. to name some), have been used to obtain accurate thermal conductivity values (Reidy and Rippen 1971). The unsteady state techniques are generally preferred for extensive experimental measurement. The heated probe technique offers several unique features as short response time, low cost and simplicity and is one of the popular unsteady state methods employed (Sweat 1974; Drouzas and Saravacos 1988; Wang and Kolbe 1990; Zheng and Huang 1998). This probe technique was originally developed for measuring the thermal conductivity of insulated material (Hooper and Chang 1950; Reidy and Rippen 1971) and its application was then extended to food system. In this study, a simple conductivity probe was successfully developed and used to measure the thermal conductivity of banana, apple and papaya fruit samples. An attempt was also made to correlate this parameter with texture and extent of ripening of the fruit. This system could offer an economically attractive and fast measurement technique that could be extended to quality control of a variety of liquid, semi-solid and solid foods.

Theoretical aspects : Unsteady state measurements involve dynamic response of a food system. Dynamic response of a system is measured either by a step change or by an impulse. During a step change, the system is subjected to a new parameter such as temperature, pH, colour. Whereas, if an impulse is used, the parameter is perturbed only for a short time and then it goes to the old value e.g., like injecting a dye or acid shot. Measurement of the thermal conductivity using heated probe is based on the principle that the temperature rise at a point close to a line heat source in a semi infinite solid subjected to a "step change" heat source is a function of time, the thermal properties of solid and the source strength. The mathematical expression with various other parameters is as follows :

$$\kappa = \frac{Q \ln [(t_2 - t_0)/(t_1 - t_0)]}{4\pi (T_2 - T_1)} \quad \ldots\ldots (1)$$

κ =thermal conductivity of probe (W/m °C),

Q = the continuous line source strength (W/m),

t_1 and t_2 are two arbitrary times (seconds) for the initiation of the line heat source,

t_0 = the time correction factor

T_1 and T_2 = the temperatures at the times t_1 and t_2 respectively.

A time correction factor (t_0) was introduced to correct the effect of finite heater diameter and finite heat resistance between the heat source and the sample (Van der Held, 1949). Derivation of equation has been reported by Nix et al (1967) and Baghe Khandan (1978). After an initial transient period, a plot of temperature versus the logarithem of time is linear until heat penetrates into the sample boundary so that its slope is $Q/4\pi\kappa$. Thus the thermal conductivity is calculated from the following equation (2) (Sweat 1974).

$$\frac{\Delta T}{\Delta \ln t} = \frac{Q}{4\pi\kappa} \quad \ldots\ldots (2)$$

Thermal conductivity meter (TCM) set up : The thermal conductivity measurement setup (heated probe type) was developed in-house and banana, apple and papaya were used for measurement of thermal conductivity. The fruit samples of banana, apple and papaya were obtained from the local market, Mumbai. Banana (variety-*Basrai*) was peeled off prior to testing to avoid possibility of sticky layer of latex on the probe that may affect the accuracy of measurement. Since, the present method involves destructive testing of the sample, this precaution is acceptable. During the experiments, whole apple and papaya fruits were taken while banana was sliced to 3 cm for convenience of handling.

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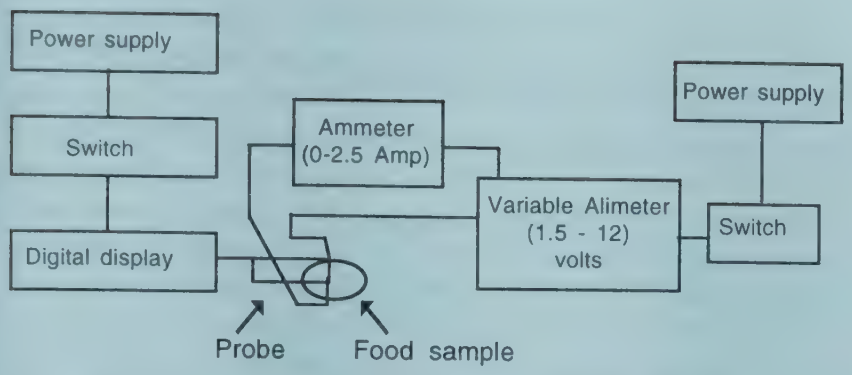

Fig. 1. Thermal conductivity meter (TCM) setup

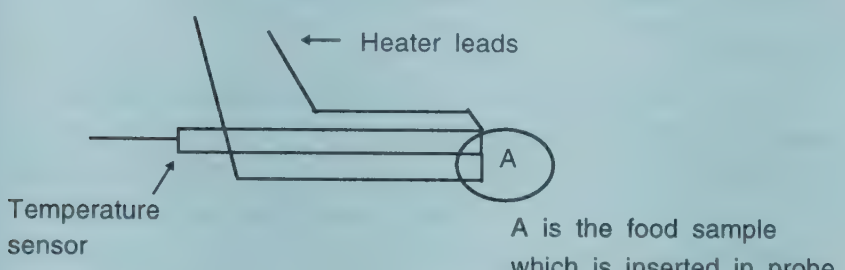

Fig. 2. Cross section of the thermal conductivity probe

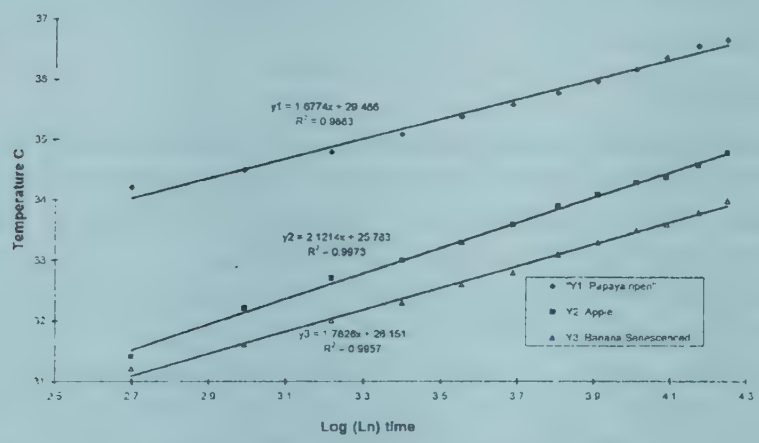

Fig. 3. Lograthmic time-temperature relationship

The performance (in terms of accuracy and sensitivity) of this method mainly depends on the probe. The probe consists of nichrome heater wire (0.03 cm in diameter, 6.2 cm in length) and a temperature sensor with a digital display (Skan Temp Scanner). An A.C. power supply was fixed to provide power to the heater wire. The voltage was fixed to some constant value by variable alimeter (Sanyo A.C. Adaptor) and current were measured to the nearest 0.1 Amp. by an ammeter connected in the series. A typical TCM set up based on heated probe is shown in Fig. 1 and the cross section of the probe is depicted in Fig. 2.

Before measuring the thermal conductivity of a sample, the probe was equilibrated at room temperature and then inserted into the sample. Initial sample temperature was recorded, then the probe heater was activated by passing electric current. Probe temperature was recorded for every 5 sec. After 90 sec, the probe heater was turned off. From time and temperature data, a linear regression line was fitted as shown in Fig. 3. The power level used to heat the probe was 3.69-3.96 W/m. A fresh fruit sample was taken every time and seven independent sets of observations were obtained to arrive at mean thermal conductivity of that fruit.

Calibration of TCM : The experimental observations are affected by several types of error (random, apparatus and systemic). The random error (personal) cannot be controlled. The apparatus and systemic errors could be eliminated by calibrating the probe using a solution with know thermal conductivity. This will also allow correction for the heat losses, difference in conversion of electric energy to heat energy and zero errors of the instrument. The thermal conductivity probe used was calibrated using a mixture of distilled water and 0.4 % agar (by wt.) and a factor of 3.143 was obtained. Thus, the actual value of thermal conductivity was obtained by multiplying this factor to the apparent value of the thermal conductivity measured.

Water contents : Water content of all banana samples was measured by drying in oven at 80°C until a constant weight was obtained. All the readings were taken in triplicate and a mean value was used to arrive at the water content-thermal conductivity correlation.

Texture measurement : The texture of different fruits was measured by Texturometer (Stven Lfra Texture Analyzer) using needle probe (TA-9), with 10 mm penetration at a speed of 1 mm/sec under normal cycle. The results were expressed as load in gram penetrating the sample.

The thermal conductivity probe developed in-house was used to measure the thermal conductivity of different fruits viz., banana, apple and papaya at various stages of ripening. The experimental values of thermal conductivity (Table 1) compared closely with those reported in the T1 literature value (Sweat 1974). Three different stages of ripening of banana were selected (mature, ripe and over ripe) to evaluate the TCM technique as a quick and simple method to correlate the quality. During ripening of banana, many biochemical changes coupled with some physical changes occur. The water content of banana pulp increases from 69 (± 4) to 74 % (± 3) (Kotecha and Desai 1995) during ripening. The increased amount of water is possibly derived from the respiratory breakdown of carbohydrates and due to osmotic transfer of moisture from peel to pulp. A fruit like banana can be visualized as a heterogeneous system containing dissolved sugar and small solutes suspended and partially solublised macromolecules like starch with large amount of water. Typically, the solid will tend to decrease the thermal conductivity whereas free water will increase this value. Obviously, one expects a high correlation between water content and the thermal conductivity. Similar correlation between water content and thermal conductivity was also reported by Choi and Okos (1983),

TABLE 1. THERMAL CONDUCTIVITY OF SELECTED FRUITS MEASURED IN THIS WORK

Fruit	Stage of maturiy	Water content, %	κ apparent	κ (thermal) conductivity) W/m °C
Banana	Unripe	70.67	0.154	0.485 ± 0.037
	Ripe	74.53	0.162	0.51 ± 0.022
	Over ripe	76.85	0.166	0.524 ± 0.007
Apple	Unripe	-	0.142	0.44 ± 0.018
Papaya	Unripe	-	0.158	0.50 ± 0.053
	Ripe	-	0.180	0.57 ± 0.024

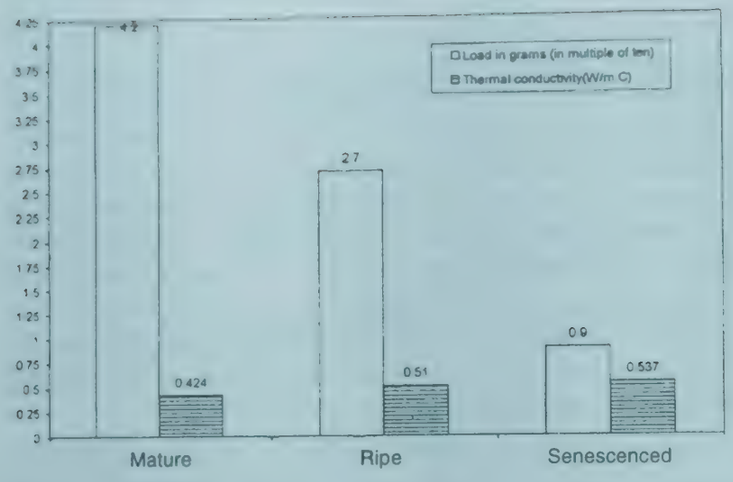

Fig. 4. Relationship between conductivity and texture of various stages of ripening of banana

Mohsenin (1980) and is applicable not only for fruits and vegetables but also for meat, poultry, fish, dairy products, fat and oils, sugar based solutions, wine and water-alcohol mixture, etc. Sweat (1974) developed a model for thermal conductivity measurement of high moisture foods using water content as a parameter and evolved the following regression equation, $\kappa = 0.00493\ w + 0.148$; where 'κ' = the thermal conductivity in W/m °C, 'w' = the moisture content of banana (%). Normally if water content is made sole criterion for comparison, apple is expected to give higher thermal conductivity. However, significant amount of trapped air (which is a bad conductor of heat) in apple tissue gives a lower conductivity value. Another biochemical change during ripening is breakdown of starch into sugar (both reducing and non-reducing). This will tend to increase conductivity of the ripened fruit. Ripening also leads to conversion of protopectin to pectin and finally to pectic acid due to action of pectinase enzyme naturally produced in the fruit at that stage. This causes softening of banana tissue. Some cellulose constituents (cellulose, hemicellulose and lignin) degrade to sugar giving rise to soft texture. During ripening, acidity of fruits is known to change. All these factors contribute positively for the thermal conductivity causing increase in value. It can be clearly seen from Table 1 that based on measurement carried out in this study the thermal conductivity of banana increased with the extent of ripening. The load (g) required by probe to penetrate into the sample was measured by terxturometer. The texture of banana samples at different stages of ripening was measured by texturometer. Unripe banana requires more load for penetration compared to ripe and over ripe samples. It can be seen from Fig. 4. that softness of banana was directly dependent on the extent of ripening and was coupled with an increase in conductivity. The following correlation between the water content and thermal conductivity was observed in the present study.

$$\kappa = 0.0063\ m + 0.038$$

where, 'κ' = the thermal conductivity in W/m °C

'm' = the moisture content of banana (%).

Thermal conductivity was also measured at different temperatures ranging from 15° to 35°C. Temperature did not show much influence on conductivity as expected (Sweat 1995). Thus, it can be seen that the line source technique worked well for collecting data on thermal conductivity of fruits. Since each conductivity test required only 90 sec, the limiting factor during data collection was sample preparation and handling rather than the actual thermal conductivity measurement. The TCM setup was very cheap, costing less than Rs. 1500/-, which is an affordable price. It is compact, easy-to-handle and requires small amount of sample. This technique can be extended to various types of fruits, vegetables and other products to correlate with the quality.

Conclusion

The thermal conductivity probe method suitable for measuring the thermal conductivity of fruits and vegetables was studied. The technique requires less quantity of sample (10 g), short time and a low cost equipment setup. A correlation among degree of ripening, water content, texture and thermal conductivity of banana was observed. Thermal conductivity did not change significantly over a temperature range of 16-32°C and at a constant temperature, it was strongly dependent on the water content of the food.

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RESEARCH NOTE

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Effect of Temperature and Storage Time on Chevon and Beef Protein Gels

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Chevon (goat meat) proteins solubility and gel strength were studied along with effect of storage time as well as temperature and compared with beef. The percent of protein solubility of goat meat proteins had higher values than beef proteins, but no significant difference was observed in gel strength values. Protein solubility increased with storage time, while gel strength decreased in both species. This could be due to proteolysis during storage, causing differences in the size of protein aggregates. The storage temperature employed had no significant effect on the variables studied. Chevon proteins were as good as beef proteins in their gel strengths.

Keywords : Chevon, Beef, Protein solubility, Gel strength.

Meats of old goats are often tough and less acceptable (Einsminger and Park 1986). On the other hand, meats of the young animals are soft and specially produced in some regions of Mexico (Gonzales 1977). The use of chevon as a protein source can be achieved by improving functional properties of meat proteins. In muscle foods, protein solubility reflects the extracted state of the protein rather than the degree of hydration (Ziegler and Foegeding 1990). Protein solubility is the most important functional property since others such as gelling and emulsifying properties are directly affected by solubility (Wilding et al. 1984; Kretszchmar 1992). Gelation of meat protein is responsible for fat and water holding in meat products. In this way, quality of meat products is defined by the functional properties of muscle proteins and these are related to process and environmental conditions (Kretzschmar 1992). The objective of this study was to compare protein solubility and gel strength of goat meat and beef proteins and to evaluate the effect of temperature and storage time on these functional properties.

Meat samples : Beef and chevon (*Psoas major*) were obtained in local abattoirs at approximately the same post-mortem time (36-48 h). Connective tissue and fat were removed from the samples, and then cut into 50 g pieces, vacuum packed and randomly distributed in the treatments.

Protein extraction : Myofibrils were extracted according to a modified method reported by Xiong and Brekke (1989). Myofibrillar systems are more closely related to processed meats than is myosin (Xiong 1994). Meat (25g) was mixed with 4 vol. of a low ionic strength solution (0.1 M sodium chloride, 50 mM sodium phosphate pH 7.4, 5 mM ethylene diamine tetra acetic acid, 1mM sodium azide) in a conventional blender for 90 sec at maximum speed. The homogenate was centrifuged at 10,000 x **g** for 15 min and the pellet was resuspended in the blender in 4 vol. of the same solution for 30 sec. The protein pellet was then washed with magnetic stirring for 90 min at 4°C and centrifuged at 2,000 x **g** for 15 min. This step was repeated 3 times, and finally the pellet was re-suspended in a high ionic strength solution (0.6 M sodium chloride, 50 mM sodium phsophate pH 6.0, 1 mM sodium azide). The protein content was determined by the biuret reaction (Gornall et al. 1949) and the solution adjusted to 15 mg/ml with the high ionic strength solution.

Gel strength determination : Protein gels were formed on heating 10 g of protein extract in test tubes (13 mm x 80 mm) in a water bath from 25 to 60°C, with a 1°C/min heating-rate, cooled in an ice bath and immediately used for compression test. Gel strength was determined by a modified method of Hickson et al (1982), using an Instron Universal Testing Machine Model 4502 (Instron Corp., Canton, USA). The samples were compressed 75 % (30 mm) with a 6 mm ∅ probe at a constant speed of 0.167 mm/sec with a 10 N load cell. The maximum force registered during gel penetration was reported as gel strength.

Solubility : The protein suspension (10 ml) was centrifuged at 25,000 x **g** for 30 min. The protein content remained in the supernatant was reported as percentage of soluble protein in relation to the initial concentration.

Experimental design : A complete 2 x 2 x 3 factorial design was used with the following variables and levels: animal species (goat and beef), storage temperature (4 and -20°C) and storage time (0, 1, 2 and 3 weeks). Results were analyzed using the PROC ANOVA in the SAS statistical system 6.02 (SAS Institute, Cary, North Carolina). Results are the mean of at least three replicates for each factorial level.

Animal species and storage time affected protein solubility ($P>0.0043$ and $P>0.04322$, respectively), whereas gel strength was affected only for storage time ($P>0.0079$) but not by animal species ($P>0.5849$). Fig. 1 and 2, show that solubility of chevon proteins was higher than that of beef protein. Solubility generally increased with storage time, the change being faster in chavon than in beef. This indicates that the

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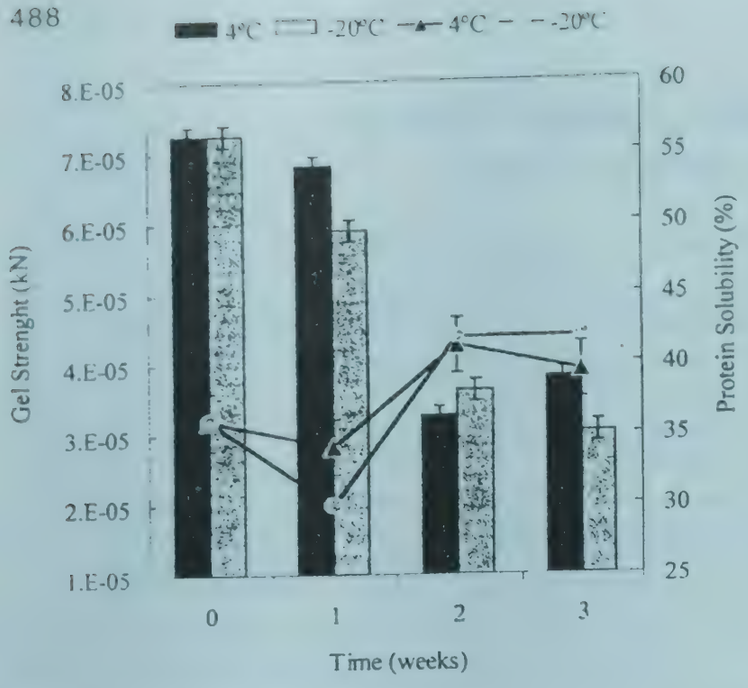

Fig. 1. Gel strength (bars) and protein solubility (lines) for beef stored at 4 and -20°C

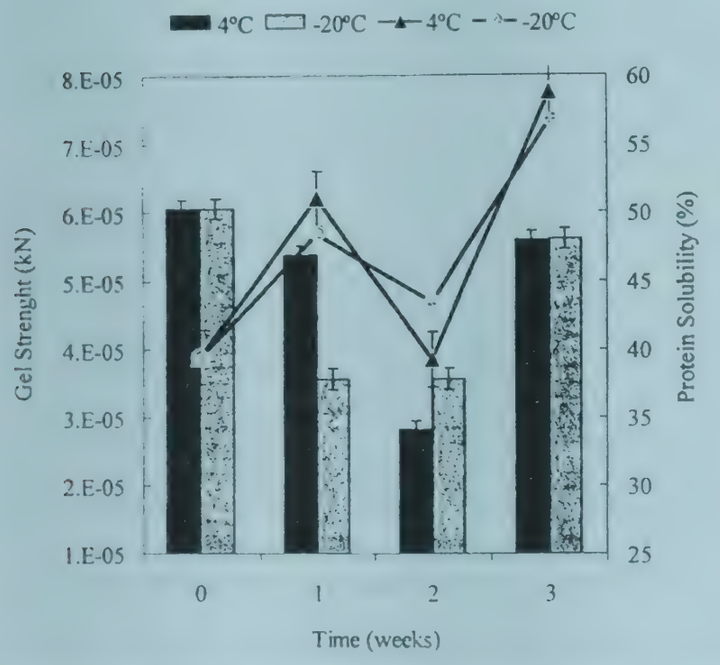

Fig. 2. Gel strength (bars) and protein solubility (lines) for goat meat stored at 4 and -20°C

goat meat proteins suffered a greater degradation. However, the temperature differences in protein solubility in both species are not significant (P>0.8683). Storage time allows denaturation that reduces the ability of protein to interact with the surrounding medium, forming clusters or large insoluble aggregates (Jimenez-Colmenero and Borderias 1983). In this study, the storage period improved protein solubility.

Gel strength for beef decreased with storage time, with no statistical difference between 4° and -20°C (P>0.6160). For goat meat protein gels, an increase in gel strength was detected at the third week of storage. This change could be due to substantial increase in protein solubility. Xiong and Brekke (1989) reported that the increase in gel strength could be attributed to the increase in protein solubility over storage time, which can also be related to the increase of myosin/actin ratio in the extracts during storage. In this way, even if protein concentration was standardised in all samples, the molecular size or aggregation formation before, during, and after heat treatment could not be the same. Differences in gelation properties between species had been previously reported (Lan et al. 1995). Intrinsic differences in animal species and muscle composition promoted biochemical changes during the storage time at different temperatures. In conclusion, the results showed that goat meat proteins as well as the beef proteins had almost similar gel properties. Storage time promoted protein degradation, which was directly related to proteins functional properties. The results of this study, further showed that temperatures employed had no significant effect on these properties.

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RESEARCH NOTE

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Mode of Inhibition of *Aspergillus flavus* IARI Antifungal Substance Produced by *Lactococcus lactis* subsp. *lactis* CHD 28.3

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The possible mode of inhibition of antifungal substance (AFS) in the cell-free supernatant from *Lactococcus lactis* subsp. *lactis* CHD 28.3 was studied *in vitro* against the indicator mold *Aspergillus flavus* IARI. The AFS appeared to exert a lethal fungicidal effect on the young conidiophore stalk especially before vesicle differentiation of the mold could take place as a part of asexual reproduction. Eventual release of cytoplasmic materials from the tip portion of conidiophore induced by AFS was also discernible. The microscopic examination also revealed the antagonistic effect of AFS on the overall asexual reproduction, resulting into anomalous environment that hindered growth of mold mycelia to reach the conidial stage and retarded growth of the conidiophore.

Keywords : *Lactococcus lactis* subsp. *lactis* CHD 28.3, AFS, *A. flavus,* Mode of inhibition.

Lactic Acid Bacteria (LAB) are well known as dairy starter organisms for their versatile industrially important virtues, which are chiefly exploited during the manufacture of a variety of fermented foods. Amongst the various scions of LAB, the *lactococci* are enviably placed for their multifaceted attributes as starter cultures. Their judicious application makes possible the manufacture of *dahi, yoghurt, srikhand, kefir, kumiss, cheese* and other fermented products in dairy industry. These food grade organisms primarily find their application in the preparation of fermented foods known for their exotic flavours as well as healthful attributes by inhibiting spoilage and pathogenic microflora (Muriana and Klaenhammer 1991; Gupta and Batish 1992). Their usefulness has also been visualized and established in terms of probiotic and therapeutic potentials in the intestine (Salminen et al. 1996). As most of the LAB unearthed today have been armed with potent bacteriocin or bacteriocin - like inhibitory substance (BLIS) lethal to a number of Gram-positive pathogens as well as spoilage organisms, the information regarding the antifungal potentials of LAB and their possible mode of action against the mold growth has remained a mystery. This situation has offered ample opportunity to have an in depth insight concerning the possible mechanism of inhibition mediated by the antifungal substance (AFS) from one of our potent antifungal isolates *Lactococcus lactis* subsp. *lactis* CHD 28.3. This particular strain quite interestingly was found to suppress the growth of *A. flavus* IARI, *A. flavus* NCIM 555, *A. parasiticus* NCIM 898, *F. pallidoroseum* and *F. chlamydosporeum* (Roy et al. 1996). The nature of the antifungal substance produced by this test culture was found to be proteinaceous. In the present investigation, an attempt has been made to reveal the possible modus operandes of the AFS produced by the test lactococcal culture against the most sensitive indicator mold namely *A. flavus* IARI with special reference to effect on mold germination and subsequent events during mycelial development.

Bacterial culture : Lactococcus lactis subsp. *lactis* CHD 28.3, the subject of this study, was a wild isolate from a cheddar cheese sample as described previously (Roy et al. 1996).

Mold culture : The indicator mold selected for this study was *Aspergillus flavus* IARI and was obtained from Molecular Biology Unit, Dairy Microbiology Division, National Dairy Research Institute, Karnal.

Preparation of spore suspension : Aspergillus flavus IARI was activated on PDA slants (pH 3.5 to 4.0). After 5 days of incubation at 30°C, the mold growth on the slant was aseptically scrapped out using 10 ml sterile saline water (150 mM NaCl) having 0.1% Tween80 (SD Fine Chemicals, Mumbai, India). The suspension was subjected to instantaneous vortexing in order to disperse the spore clumps. Spore count was then determined with the aid of haemocytometer (Fein-Optic Jena, Germany) as described previously (Roy et al. 1996) and the suspension was standardized to a final concentration of 10^7 spores per ml.

Preparation of cell free supernatant : An aliquot of 10 ml of Elliker's broth, pH 7.0 was inoculated with activated 16 h old culture (CHD 23.8) at 1% level and incubated at 30°C for 48 h. The crude supernatant fluid was collected in a sterile vial and subsequently, used for cut well assay.

Cut well agar assay : The mode of inhibition of the antifungal substance (AFS) in the cell free supernatant was determined by agar well method (Batish et al. 1991; Roy et al. 1996). Twenty five ml of the molten potato dextrose agar supplemented with 0.1% Triton X-100 (Sigma Chemicals, USA) was aseptically transferred to the sterile petriplates and was allowed to solidify. An aliquot of 50 µl of mold spore suspension was spread uniformly over the agar surface with a sterile cotton swab. The plates were then dried at 37°C for 1 h and wells of 6 mm diameter were cut with sterile well borer. The wells were then filled with 200 µl of cell-free supernatant of the test culture. The plates were then incubated at 25°C for 12 to 16 h to facilitate the diffusion of culture supernatant fluid into the agar medium. Later, the plates were inverted and incubation continued for 2 to 5 days followed by examination for clear inhibitory zone

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formation around the wells. The plates having wells filled with uninoculated Elliker's broth served as negative control.

Microscopic examination : The normal mold growth on the negative control plate was microscopically examined both under 40X and 100X after staining with crystal violet. Along with this, tiny whitish convex isolated growth in the peripheral region of the clear inhibition zone around the wells of test / experimental plate was aseptically picked and teased apart on the grease-free slide followed by heat fixation and mono-staining with crystal violet and examined under the oil immersion lens (Leica). The observations pertaining to the changes in the growth and structure of mold mycelia, conidiophore and conidia and their germination were recorded periodically (1-5 days) at cellular level.

The antifungal activity of the culture supernatant from *L. lactis* subsp. *lactis* CHD 28.3 against *A. flavus* IARI based on cut agar well assay after 3 days of incubation has been recorded in Plate 1. The formation of clear zones of inhibition of the indicator mold around the wells filled with the culture supernatant clearly indicates the fungicidal action of the test culture. After establishing the antifungal activity of the test culture on agar plates by cut well agar, attempts were then made to look at the gross morphological changes in the growth of the indicator mold under the microscope when the mold spores were subjected to the culture supernatant having antifungal factor. The nature of the AFS was found to be proteinaceous as has been reported previously (Roy et al. 1996). The morphological picture of the indicator mold after treatment of the mold spores with the culture supernatant from the test culture at different time intervals has been presented in Plates 2-6. The suppression of the mold growth by the antifungal substance appears to occur in a phased manner or a time dependent interaction between the two. However, eventually the antifungal substance brings about the lysis of the targeted mold mycelia, thereby, suggesting fungicidal action of the AFS produced by the test culture. The overall picture shown in Plate 2 depicts the lethal effect of the AFS produced by the test culture on the young conidiophore stalk just prior to vesicle differentiation during initial stages of germination of the treated mold spores (after one day). As is quite evident from the picture profile, the exposure of the spores to antifungal substance appear to have caused damage to the mold mycelia developed immediately after their germination as indicated by abrupt release of cytoplasmic material from the tip of conidiophores even before their development into mature vesicles. The overall morphology of the affected mold under the microscope differed considerably from that of the control samples where untreated spores developed into normal intact mycelial growth of *A.flavus* IARI within one to two days. The untreated spores germinated into full fledged mycelial growth yielding upright mold conidiophore with conidia. The latter seemed to have budded off into chains from the vesicles of conidiophore as a part of asexual reproduction ensued after spore germination. The hyphae were also well developed, profusely branched, septate and hayline with multinucleate cells.

The antifungal effect in the culture supernatant of the test culture was more pronounced during early stage of mold development (2 days) as has been recorded in Plate 3. As is quite clear from the picture, AFS produced in the culture supernatant fluid appears to act during early stage of mold development (2 days). The young slender conidiophore remained stumpy and retarded in growth as a result of AFS action of the mold and hence could not develop into a full fledged vesicle for further conidiation. The mold spores on prolonged exposure

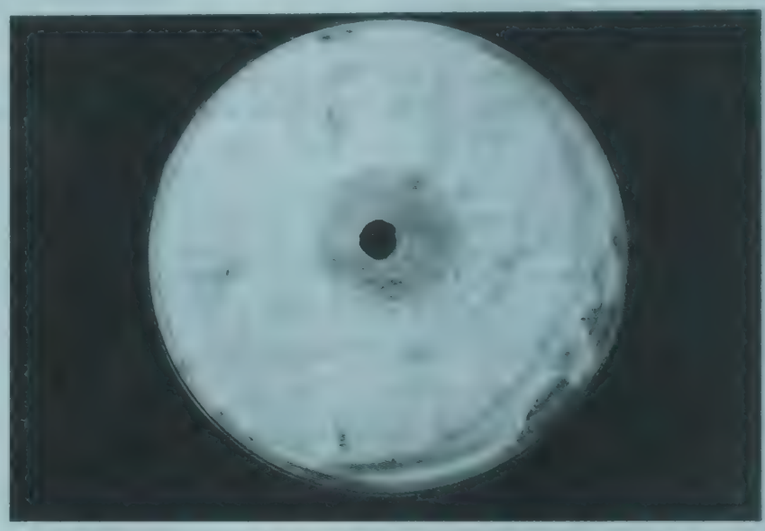

Plate 1. Fungicidal activity of *L. lactis* subsp. *lactis* CHD 28.3 against *A. flavus* IARI by cut well agar assay

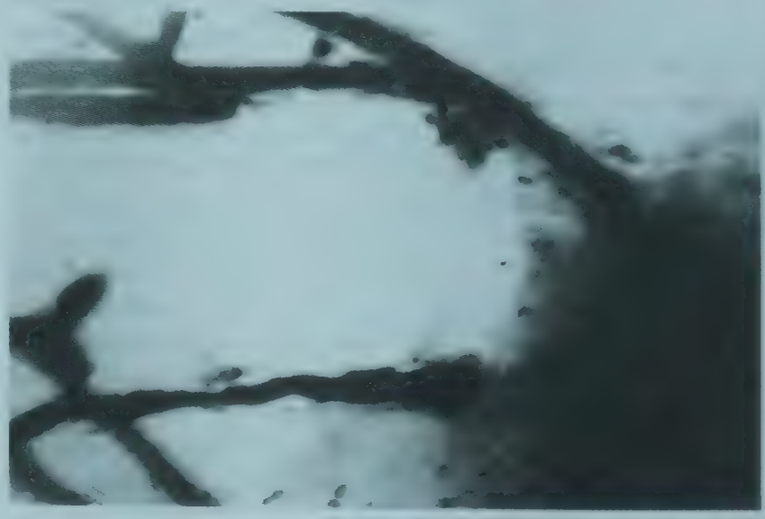

Plate 2. Microscopic picture of *A. flavus* IARI as affected by AFS from CHD 28.3 after exposure of the mold spores for one day

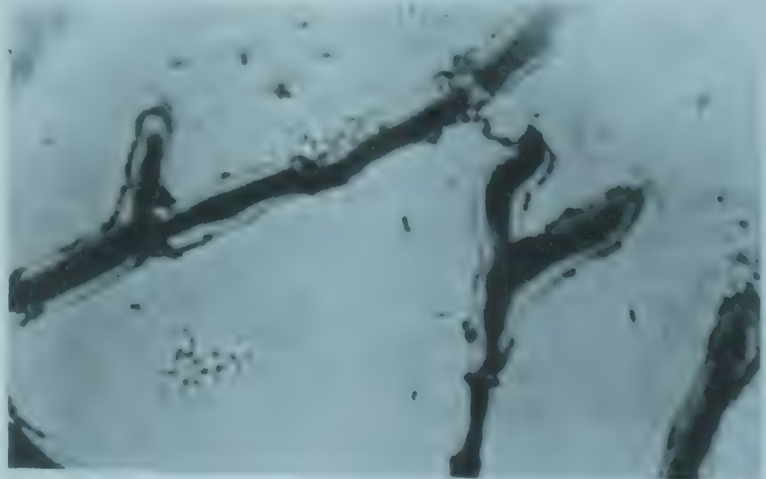

Plate 3. Microscopic picture of *A. flavus* IARI as affected by AFS from CHD 28.3 after exposure of the mold spores for two days

to AFS (3 days or more) could not germinate into full fledged mycelia (Plate 4). This picture clearly indicates that conidiophore that managed to evolve from the germinated spores could not develop into vesicles due to further interaction with AFS and thereby, entire asexual reproduction process seemed to be halted. Similarly, the picture depicted in Plate 5 further describes the incomplete organization of vesicles during late developmental stage (4 days) in presence of AFS and this anomalous situation might have hindered the normal growth of mold mycelia to reach the conidial stage.

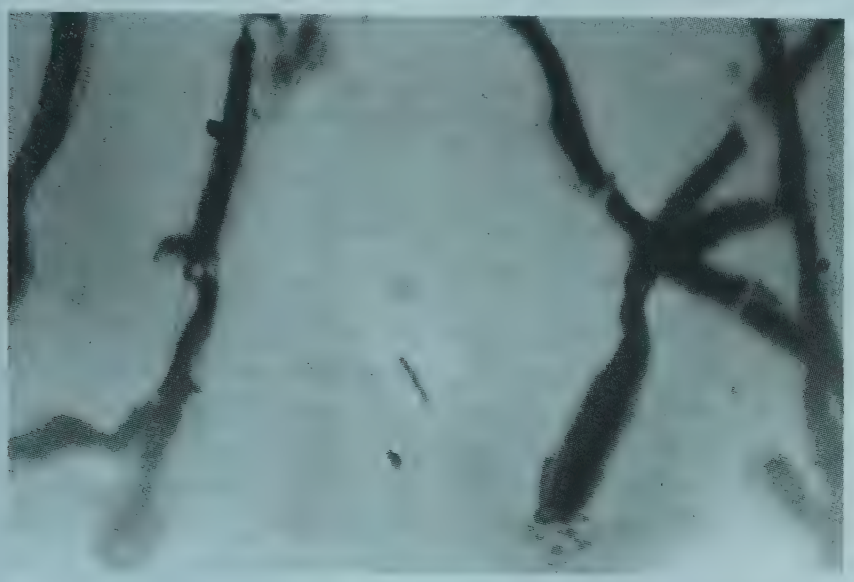

Plate 4. Microscopic picture of *A. flavus* IARI as affected by AFS from CHD 28.3 after exposure of the mold spores for three days

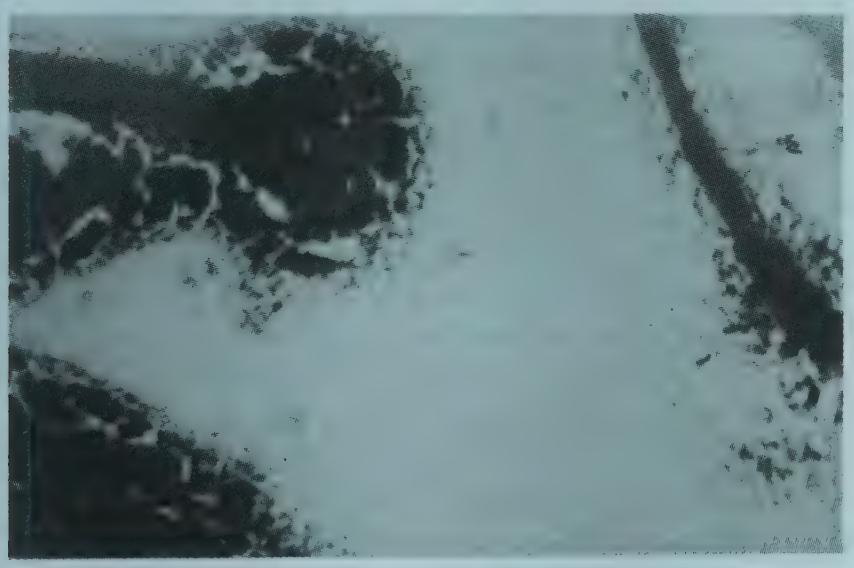

Plate 5. Microscopic picture of *A. flavus* IARI as affected by AFS from CHD 28.3 after exposure of the mold spores for four days

Plate 6. Microscopic picture of *A. flavus* IARI as affected by AFS from CHD 28.3 after exposure of the mold spores for five days

The continuous exposure of the mold mycelia to AFS (5 days or more) unequivocally resulted in the stunted growth along with thinning out of the conidiophore as has been revealed by the microscopic picture of the affected mold (Plate 6). From the emerging picture, it is further clear that the continuity of the conidiophore still could not be maintained as a result of AFS action which appeared to have caused disruption in the continuity of the cytoplasmic content in the conidiophore stalk.

A critical appraisal of the microscopic pictures of *A. flavus* IARI affected by the AFS at different developmental stages suggests that AFS in the culture supernatant elaborated by the test culture CHD 28.3 appeared to exert more or less a fungicidal mode of inhibition in a time dependent interaction by targeting both the spore germination and subsequent mycelial development and differentiation during asexual reproduction of the mold. The asexual life cycle of *A. flavus* can be divided into two distinct phases namely growth and reproduction, wherein, the initial phase entails all these events, leading upto and including the initiation of development as an asexually derived spore or conidium which subsequently germinates to produce hyphae that grow and branch outwards to form an undifferentiated network of interconnected cells called the mycelia (Gow and Gad 1994). The present study has shed some light on these aspects particularly with regard to different stages of mold growth and reproduction where AFS appeared to thwart the conidiophore differentiation to vesicles and conidiation (Plates 2 to 6). The present findings have corroborated the observations of Gourama and Bullerman (1995) who reported that the culture supernatant of *Lactobacillus* spp. inhibited *A. flavus* quite effectively and lowered down the elongation process of germ tubes as compared to the control which formed branched conidial hyphae. These workers also observed that the mold mycelia in the control had formed heads with heavy sporulation as compared to the germinated molds treated with AFS, which had just begun to form branched hyphae. However, they reasonably explained that the reduction in the elongation in the germ tubes in the presence of *Lactobacillus* spp. cell-free supernatant could be the result of a combination of factors such as metabolic inhibitors and acidic pH. In this context, the present investigation has revealed that the inhibition at the conidiophore stage through various modes of action are mediated by certain antifungal principles i.e. proteinaceous factors and acidic pH as has also been suggested by Gow and Gadd (1994). The formation of the clear zones of inhibition of mold growth in our agar cut well assay clearly demonstrates the fungicidal / mycocidal effect of the antifungal substance present in the culture supernatant of the test culture. However, more extensive work needs to be carried out on these lines to substantiate these findings after purification and characterization of the antifungal polypeptide / peptide produced by the test lactic acid bacterial culture.

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Quality of Buffalo Meat Sausages Containing Decolourized Globin Protein Isolate

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Decolourised globin protein isolate was prepared from Red Blood Cell (RBC) concentrate of buffalo blood. Buffalo meat sausages were prepared by replacing lean meat at 0, 3, 6 and 9 % with globin protein Isolate (GPI). The emulsion stability, emulsion pH, cooking yield, moisture content and lipid content decreased and shear force value, protein and ash content of buffalo meat sausages increased with increased level of GPI. The sensory attributes viz, appearance, flavour, juiciness, texture mouth-coating and overall acceptability scores reduced marginally and were good up to 9% replacement of lean.

Keywords : Globin protein isolates, Sausages, Quality.

In the Indian slaughter houses, a huge quantity of animal blood which contains high quality protein goes waste. In the recent years attention has been paid for the possible use of blood proteins in food (Dill and Landmann 1988; Mandal et al. 1999). They are used primarily to increase the protein contents, to enhance the water holding capacity and emulsifying capacity (Tybor et al. 1973; Mandal et al. 2000).

Incorporation of whole blood or RBC concentrate in meat products, gives a dark colour to the product after cooking (Tybor et al. 1973; Dill and Landmann 1988). Therefore, efforts were necessary to prepare decolourised globin protein isolates (GPI) for the proper utilization of RBC concentrate in foods. The possibility of incorporation of GPI in sausages was tried by Caldiromi and Ockerman (1982). They reported that sausages containing 1 - 1.5% globin showed no appreciable change in sensory quality. Hazarika and Biro (1993) added GPI in lecso - sausages and found no adverse effect on the quality and acceptability. There are no reports available in the literature on utilisation of buffalo RBC concentrate in sausages.

In the present study, an attempt was made to study the effect of incorporation of decolourised GPI on the physical, chemical and sensory attributes of buffalo meat sausages.

Globin protein isolate was prepared by removing the haem group from haemoglobin with the help of sodium alginate and acetone following the method described by Tybor et al (1973) with suitable modification (Mandal 1996).

Buffalo meat sausages were prepared by a standardized recipe incorporating GPI at 0, 3, 6 and 9% levels, replacing the lean meat (Table 1). GPI was rehydrated to the moisture level of 70% and neutralized before incorporation to emulsion.

Meat emulsion was prepared in Hobart Planetary mixer (Model No. N-500). Partially thawed minced meat was chopped with chilled water, salt, phosphate, sugar, nitrate along with protein isolate. Refined mustard oil was added gradually and blended. Then dry spices and green condiments were mixed. Finally, the meat emulsion obtained was stuffed into synthetic casting of 25 mm diameter and linked manually at 10 cm length. Cooking was done in steam for 30 min to an internal temperature of 70-75°C.

The pH of raw emulsions as well as cooked sausages and the proximate composition were determined by the method of AOAC (1980). Emulsion stability was determined by the method of Baliga and Madiah (1970) with minor modifications and calculated as per the formula given below.

$$\text{Emulsion stability \%} = \frac{\text{Weight of emulsion after heating}}{\text{Weight of emulsion before heating}} \times 100$$

Cooking yields were calculated by taking the weights of raw and cooked sausages and expressed in percent. Shear force value was determined according to Berry and Stiffler (1981) by using Warner Bratzler shear press apparatus. At least 5 observations were taken for each sample and the average reported.

Organoleptic evaluation of the product was conducted by subjecting the cooked sausages to a semi trained panel using 8 point Hedonic scale (Keeton 1983) where 1 represented the lowest and 8 the highest preference for the attribute.

Three trials were conducted and the data obtained were statistically analysed by one way classification of analysis of variance (Snedecor and Cochran 1980).

The emulsion stability ($p < 0.01$), emulsion pH ($p \leq 0.05$) and cooking yield ($p \leq 0.05$) reduced significantly with the increased level of GPI incorporation (Table 2). The lower emulsion stability might be attributed to lower functional properties of GPI

TABLE 1. RECIPE OF BUFFALO MEAT SAUSAGES ALONG WITH REPLACEMENTS

Ingredients	% lean replaced			
	0	3	6	9
Buffalo meat	85.0	82.4	79.9	77.4
Protein isolate	0.0	2.6	5.1	7.6
Mustard oil	15.0	15.0	15.0	15.0
Total	100.0	100.0	100.0	100.0

Other ingredients (same for all) % : Green condiments 5.0, Table salt 2.0, Dry spices 1.5, Sugar 1.0, Sodium nitrate 0.02 and Ice water 12.0 ml.

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TABLE 2. EFFECT OF INCORPORATION OF DIFFERENT LEVELS OF GLOBIN PROTEIN ISOLATE ON THE PHYSICO CHEMICAL AND SENSORY ATTRIBUTES OF BUFFALO MEAT SAUSAGES

	% lean replaced with GPI			
Parameters	0	3	6	9
Physico-chemical properties				
Emulsion stability	96.6 ± 0.06^{D}	95.1 ± 0.06^{C}	93.3 ± 0.06^{B}	91.7 ± 0.04^{A}
Emulsion pH	6.1 ± 0.03^{D}	5.9 ± 0.01^{C}	5.8 ± 0.02^{B}	5.8 ± 0.04^{A}
Cooking yield, %	96.4 ± 0.14^{D}	95.3 ± 0.08^{C}	93.4 ± 0.02^{B}	93.1 ± 0.04^{A}
Shear force value, kg	1.6 ± 0.02^{A}	1.7 ± 0.03^{B}	1.8 ± 0.02^{C}	1.9 ± 0.03^{D}
Moisture, %	64.9 ± 0.22^{D}	63.4 ± 0.07^{C}	61.3 ± 0.04^{B}	60.0 ± 0.07^{A}
Protein, %	16.6 ± 0.07^{A}	17.8 ± 0.03^{B}	19.3 ± 0.16^{C}	20.5 ± 0.12^{D}
Lipids, %	12.7 ± 0.07^{D}	12.5 ± 0.06^{C}	12.3 ± 0.05^{B}	12.1 ± 0.04^{A}
Ash, %	2.4 ± 0.05^{A}	2.8 ± 0.07^{B}	3.6 ± 0.06^{C}	4.4 ± 0.06^{D}
Sensory characteristics				
Appearance	6.7 ± 0.12	6.3 ± 0.13	6.4 ± 0.14	6.5 ± 0.16
Flavour	6.7 ± 0.14	6.4 ± 0.15	6.5 ± 0.17	6.3 ± 0.14
Juiciness	6.5 ± 0.20	6.0 ± 0.15	6.3 ± 0.19	6.0 ± 0.22
Texture	6.4 ± 0.16	6.3 ± 0.15	6.2 ± 0.16	6.2 ± 0.23
Mouth coating	7.0 ± 0.20	6.9 ± 0.17	7.0 ± 0.15	7.0 ± 0.17
Overall palatability	6.4 ± 0.18	6.3 ± 0.14	6.4 ± 0.16	6.2 ± 0.18

Values are mean ± SE of three experiments

particularly emulsifying activity. However, Caldironi and Ockerman (1982) suggested that the use of globin improved the physical properties of sausages. Hazarika and Biro (1993) reported non significant effect on pH of porcine sausage emulsion. The yield of meat product actually depends on the protein quality which bind water and fat. The GPI is found to have comparatively lower functional properties which led to incomplete holding of water and fat and lower cooking yield than the control.

The shear force values had increased significantly ($p \leq 0.01$) with the increase of GPI levels. This might be due to partial drying effect. Due to improper holding of water and fat, the sausage became little harder. Caldironi and Ockermon (1982) also observed that GPI is not very beneficial for texture of sausages.

The moisture and lipid contents have reduced significantly ($P \leq 0.05$). However, the protein and ash contents (Table 2) have increased significantly ($P \leq 0.05$). The reduction of moisture content and increase in protein content in sausages might be due to lower water holding capacity of GPI. The reduction of fat content in sausages may be due to improper holding of fat in the emulsion. As the GPI was found to be a poor emulsifier and emulsion stability also reduced, which resulted into improper fat holding. The increase of ash content might be attributed to the partial loss of moisture and lipid with higher levels of GPI incorporation. These results are in agreement with Hazarika and Biro (1993), who reported increasing fat content which might be due to better functional properties of GPI procured from commercial manufacturer.

The incorporation of GPI had no significant ($P \leq 0.05$) effect on appearance, flavour, texture, juiciness mouth coating and overall palatability of sausages (Table 2). The results indicated that incorporation of GPI had not given any dark colour which might have affected the appearance scores of sausages. The marginal reduction in flavour scores might be attributed to the bland taste of GPI. The slight decrease in juiciness might be attributed to little loss of moisture and lipid during cooking. Overall, the results revealed that the incorporation of GPI did not cause adverse effect on organoleptic properties of sausages upto 9% lean replacement. Other workers also reported similar results in beef sausages with GPI (Caldironi and Ockerman 1982) and in pork sausage with porcine GPI (Hazarika and Biro 1993).

It may be concluded that the GPI can be incorporated in buffalo meat sausages replacing upto 9% lean meat without affecting sausage acceptability.

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RESEARCH NOTE

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Processing and Quality Evaluation of Ready-to-Serve Watermelon Nectars

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Watermelon fruits *(Citrullus vulgaris),* 'Crimson sweet' var. were processed to ready-to-serve pasteurised nectars (85°C for 20 min) at varying levels of °Brix (15, 20, 25), xanthan gum % (0.10, 0.20, 0.25), citric acid % (0.10, 0.15, 0.20, 0.30), fortified with 1.0% ascorbic acid with or without addition of potassium sorbate. Sensory evaluation indicated that watermelon nectars with 20° or 25°Brix, 0.20% xanthan gum, 0.15% citric acid and pH 3.75-3.87 were most highly ranked and thus preferred by panelists, than nectar blends of watermelon with mango. On storage for 5 weeks at 20-25°C, there were no significant quality changes in consistency, total soluble solids (°Brix). However, there was loss of ascorbic, decreased pH and fading of colour with negligible growth of microorganisms.

Keywords : Watermelon, Mango pulp, Nectar, Pasteurisation, Storage, Physico-chemical attributes, Sensory quality.

Watermelon is the edible fruit *Citrullus vulgaris* (syn. *C. lanatus)* of the family *Cucurbitaceae.* The fruit has been known in Tropical Africa, but is now cultivated throughout the warmer parts of the world (Teotia et al. 1988). In the Caribbean, as in Trinidad and Tobago, watermelon production tend to be seasonal with an oversupply of the fruits during the dry season (January to June) and is usually grown for the fresh market. The wet season varieties are not desirable as fresh fruits as they tend to accumulate water with low sugar content (Doodnath 1998). For good eating quality, the principal requirements are flesh crispness, good flesh colour and sweetness (Teotia and Ramakrishna 1984). Fruits are harvested when the flesh is sweet, but not overripe, as they tend to become mealy and stringy (Yamaguchi 1983). Gowda and Jalali (1995) reported that the use of watermelons for processing has not received much attention except for a few earlier reports.

Crandall and Kesterson (1981) indicated that watermelon fruits consisted of 41.0% juice, 8% pulp, 1% seeds and 50% rind on wet weight basis, with 95.7% moisture. Some preliminary work has been done on the packaging and preservation of watermelon juice in cans and bottles (Ghosh et al. 1982). Saini and Bains (1994) developed a method for the mechanised production of watermelon juice using two cultivars 'H-23' and 'Shipper', while Gowda and Jalali (1995) worked on watermelon fruits of the 'Arka Manik' variety in the production of a ready-to-serve spice-based beverage. The objectives of the present study were to utilise watermelon fruits in the production of stable watermelon nectars and blended watermelon/mango nectars. Also, the changes during storage in physico-chemical, sensory and microbiological attributes of the treatments were investigated.

Fruits : Watermelon fruits of 'Crimson Sweet' variety which were obtained from a farm. They were harvested at optimum ripeness with yields of 10-14 kg since this variety can lose quality rapidly after optimum ripeness. Pulped mango *(Mangifera indica)* known as 'Common Local' variety was blended with watermelon juice. The mangoes were harvested from a single tree (to reduce variability) in a farm.

* *Corresponding Author*

Processing : Fig. 1 shows the generalised processing steps in the production of watermelon nectars. Fruits were washed, cut into halves and quarters using stainless steel knives. The juice was extracted using an Osteriser Commercial Blender and Filtered through 0.5 mm mesh to remove fibrous material. Sucrose was then added to adjust the total soluble solids, (TSS) (Table 1). The watermelon nectar treatments (Table 1) were heated to 85°C, to which xanthan gum was added in some treatments and ascorbic acid (1.0%), and then

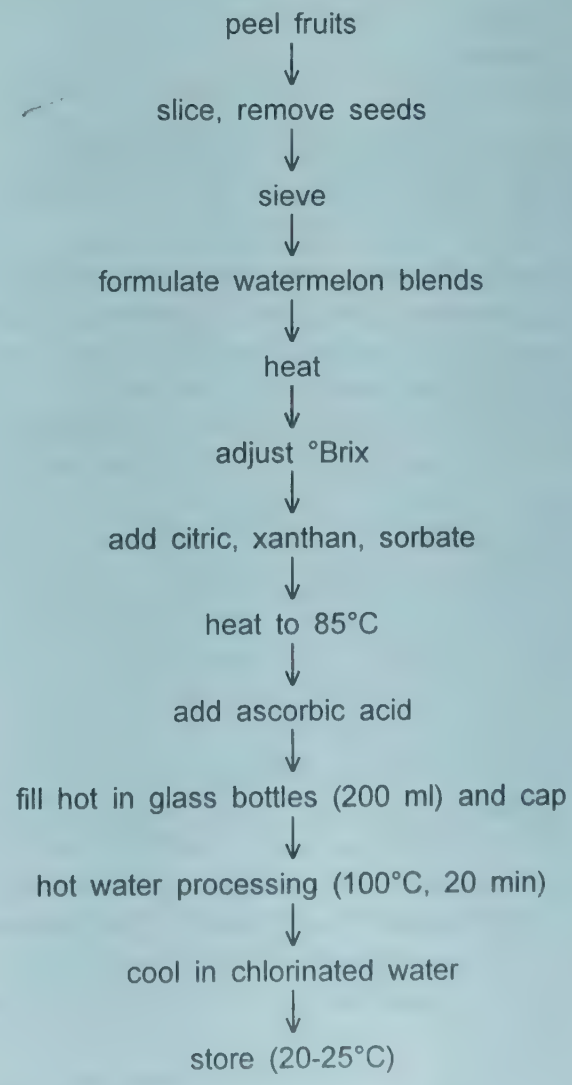

Fig. 1. Processing steps for watermelon nectars

TABLE 1. WATERMELON NECTAR TREATMENTS

T Nos.	Water-melon, %	Mango, %	TSS, °Brix	Xanthan gum, %	Citric acid, %	Sorbate, %
T1	100	–	15	–	0.30	–
T2	100	–	15	0.25	0.30	–
T3	100	–	15	0.10	0.10	–
T4	100	–	15	0.20	0.10	–
T5	100	–	15	0.10	0.15	–
T6	100	–	15	0.20	0.15	–
T7	100	–	15	0.10	0.20	–
T8	100	–	15	0.20	0.20	–
T9	100	–	20	0.20	0.15	0.10
T10	100	–	25	0.20	0.15	0.10
T11	85	15	20	0.20	0.10	0.10
T12	75	25	20	0.10	0.10	0.10

TABLE 2. PHYSICO-CHEMICAL PARAMETERS OF UNPROCESSED WATERMELON AND MANGO PULP

Parameters	Watermelon juice	Mango pulp
Colour L, a, b	32.6, 4.4, 2.1	53.2, 2.5, 36.2
TSS, °Brix	5.5 ± 0.10	16.0 ± 1.0
pH	5.04 ± 0.003	4.22 ± 0.10
Citric acid, mg / 220 ml	0.17 ± 0.01	0.44 ± 0.04
Ascorbic acid, mg / 200 ml	1.39 ± 0.08	7.02 ± 0.05
Consistency, sec to flow 24 units	3.0	>120

Means ± Standard error

filled hot into pre-sterilised 200 ml glass bottles and capped. The bottles were water-pasteurised at 100°C for 20 min using a SafGard Pres Vac home pasteuriser.

Treatments : Sensory evaluation was conducted by ten semi-trained panelists to gross screen the watermelon treatments based on acceptability (appearance, flavour and consistency). Panelists indicated that watermelon treatments T1 and T2 with the addition of 0.30% citric acid, resulted in nectars that were too acidic. In T1 (no xanthan gum addition) there was separation of the juice into layers, as a clear upper serum layer and a heavier layer, within 30 min of bottling. Panelists indicated that T2 (inclusion of 0.25% xanthan gum) was too viscous. In further experimental work, modifications were made to the preliminary treatments. On decreasing the percentage of citric acid from 0.30 to 0.10 (T3; T4), the acidic taste was not sensed. However, on further increase from 0.10 to 0.15% (T5; T6), although a slight acidity was detected, the nectars were not very acceptable. On further increase of citric acid to 0.20%, watermelon treatments (T7; T8), were of acceptable flavour. Reducing the percentage of xanthan gum from 0.25% in the preliminary treatment (T1) to 0.10% (T3; T5) resulted in separation of the suspension into layers within 16 h of bottling. The addition of 0.20% xanthan gum in watermelon treatments (T4; T6; T8; T9; T10) resulted in the stability of the suspension up to at least 5 weeks of experimental storage at 20-25°C. In watermelon nectars, T9; T10, the TSS was increased to 20-25°Brix which resulted in more acceptable flavour than prior treatments (15°Brix). Blends of watermelon/mango nectars (T11 with 15% mango pulp; T12 with 25% mango pulp), required less (0.10%) citric acid than watermelon nectars as the unprocessed mango pulp was more acidic than the unprocessed watermelon juice (Table 2). Also, potassium sorbate (0.10%) was added to some treatments (T9; T10; T11; T12). All treatments were replicated with the production of 15 bottles per batch. The bottles were stored at 20-25°C and the final selected treatments (T9; T10; T11; T12) were analysed on day 1, weeks 1, 2, 3 and 5 of processing.

Physico-chemical analyses : Physico-chemical parameters were measured on the watermelon juice, mango pulp and final nectar treatments (T9; T10; T11; T12). Colour was measured on a Minolta Chroma Meter. A 50 ml sample was transferred to a 100 ml colourless flask. The 'L', 'a', 'b' coordinates were recorded. The 'L' value represented the degree of lightness of colours, +/– 'a' represented the degree or redness or greeness and +/– 'b' the degree of yellowness or blueness. Total soluble solids (TSS) were measured (triplicate) on a hand-held refractometer and recorded as °Brix. Total titratable acidity (TTA) as expressed % citric acid was measured by titrating 20 ml aliquot of sample with 0.1N NaOH using phenolpthalein as an indicator (AOAC 1990). pH was measured on 25 ml of sample using an Orion pH meter in triplicates. Ascorbic acid (three determinations from duplicate bottles) was determined by the 2, 6-dichlorophenol-indophenol visual titration method (Ranganna 1984). Consistency (apparent viscosity) was determined using a Bostwick consistometer. The gate of the consistometer was released and the average time (sec) of 3 readings per duplicate bottles that allowed the flow of 100 ml of the sample over 24 units on the scale was recorded.

Microbial analyses : The number of aerobic microorganisms present in the samples were determined by standard plate counts (SPC) using Plate Count Agar (PCA, Oxoid. Hampshire, UK), and the plates were incubated at 32°C for 48 h. Yeasts and molds were enumerated on potato dextrose agar plates (PDA, Oxoid) acidified with 10% tartaric acid to pH 3.7 and incubated at 25°C for 3 days as outlined by Speck (1976). Colonies between 25-250 per plate were counted and reported as cfu/ml (Swanson et al. 1992).

Sensory evaluation : Panelists (20) were drawn from the staff of Eco-Engineering Consultant Ltd. and the University of the West Indies, Trinidad, W.I. Potential panelists were given a questionnaire to ascertain their level of interest in the research, availability of time for participation in sensory evaluation and as having consumed watermelon as a fresh fruit. Sensory evaluation was conducted on partitioned booth with fluorescent lights located in the Sensory Evaluation Laboratory of the Department of Food Production. Each panelist was served with the 3-digit coded watermelon products (20 ml) in clear glasses (30 ml). Nectars were chilled at 8°C for 1 h and shaken prior to serving. The panelists were asked to rank watermelon nectars, T9; T10; T11; T12 (Table 1) without bias on appearance, colour, odour and taste (# 1 least acceptable to # 4 most acceptable) with comments. Also an overall rank for preference was obtained

Statistical analyses : The data of sensory ranks were subjected to Friedman's test as outlined by Lawless and Heyman (1998). Statistical analysis of variance (ANOVA) determined the

TABLE 3. PHYSICO-CHEMICAL PARAMETERS OF PASTEURISED WATERMELON NECTARS

Parameters	T9	T10	T11	T12
Colour, L, a, b	30.5, 4.4, 3.7	29.0, 4.3, 5.4	32.3, 6.2, 7.5	32.9, 6.1, 11.2
Colour, L a, b storage (5 wks)	30.9, 4.9, 4.4	32.3, 3.5, 2.9	33.6, 5.8, 7.0	34.0 5.4, 9.0
pH	3.75	3.87	3.97	3.99
Citric acid, mg/200 ml	0.052	0.049	0.049	0.056
TSS, °Brix	25	20	20	20
Consistency, sec	1.0	0.43	18.6	110

T9 : 100% watermelon, 25°Brix, 0.15% citric acid, 0.20% xanthan
T10 : 100% watermelon, 20°Brix, 0.15% citric acid, 0.20% xanthan
T11 : 85% watermelon, 15% mango, 20°Brix, 0.10% citric acid, 0.20% xanthan
T12 : 75% watermelon, 25% mango, 20°Brix, 0.10% citric acid, 0.20% xanthan
Analyses performed 1 day after processing, except for colour on storage

TABLE 4. ASCORBIC ACID RETENTION % OF FORTIFIED WATERMELON NECTARS ON STORAGE

T. Nos.	Initial ascorbic acid mg/200 ml	Retention of ascorbic acid, % Week 1	Week 2	Week 3	Week 5
T9	0.82	100	89.2	86.6	85.5
T10	0.82	100	100	98.6	95.5
T11	0.75	98.2	95.5	93.4	89.4
T12	0.82	100	100	93.0	91.3

T9:100% watermelon, 25°Brix, 0.15% citric acid, 0.20% xanthan
T10:100% watermelon, 20°Brix, 0.15% citric acid, 0.20% xanthan
T11:85% watermelon, 15% mango, 20°Brix, 0.10% citric acid, 0.20% xanthan
T12:75% watermelon, 25% mango, 20°Brix, 0.10% citric acid, 0.20% xanthan

effect of treatment formulation and storage ($P < 0.05$) on the physico-chemical attributes with a SAS Statistical Software (SAS Institute, Inc, 1989). The sample differences were separated using a multiple comparison test of Duncan's Multiple Range Test ($P < 0.05$).

Physico-chemical attributes : Tables 2 and 3 show the physico-chemical parameters of raw fruits and pasteurised nectars respectively. The fresh watermelon juice was more bright (lower 'L' value), and red (higher 'a' value), and less yellow (lower 'b' value), when compared to the unprocessed mango pulp (Table 2). There were variations ($P < 0.05$) in colour for watermelon treatments (Table 3). Watermelon/mango blends of (T11; T12) appeared orange in colour, which were recorded as higher 'L', 'a' and 'b' values on comparison to watermelon nectars T9 and T10. The 'b' value was higher in T12, thus reflecting the higher percentage of mango pulp in the treatment (25%), as compared to T11 (15%). On storage, there was slight colour fading ($P < 0.05$) as the nectars became less dark, red and yellow (Table 3). Lycopene and carotene have been isolated from watermelons, with lycopene being responsible for the red colour (Pratt 1971). In a study by Gowda and Jalali (1995) reported that there were decreases in lycopene level and carotenoid content of watermelon juice on storage for six months at room temperature. The mango pulp had a lower pH (4.22 ± 0.10), as compared to the unprocessed watermelon juice (5.04 ± 0.003). Thus, in formulation of watermelon/mango blend treatments (T11; T12) a lower level of citric acid 0.10% was required to adjust the pH as compared to the addition of 0.20% citric acid required in watermelon treatments (T9; T10). On storage the pH values 3.70-3.99 dropped to 3.65-3.68. There was a loss of citric acid on processing (Table 2 vs Table 3) and at the end of the 5 week storage, there were further losses of citric acid, 2.3-8.5% (data not shown) in the final treatments. There was loss of ascorbic acid (%) on processing of watermelon nectars (59.08-62.82%). There were no differences ($P > 0.05$) in the ascorbic acid content between pasteurised watermelon nectars. Table 4 indicates the retention (%) of ascorbic acid on storage. Ascorbic acid is easily destroyed by oxidation, especially at high temperatures, and is the vitamin most easily lost during food processing and storage (Potter and Hotchkiss 1995). Saini and Bains (1994) reported that more than 10% of ascorbic acid was lost in watermelon juice during processing, which increased to 28-35% after 26 weeks of storage. There were significant differences ($P < 0.05$) in consistency of watermelon treatments (Table 3). Table 3 indicated that watermelon/mango blended nectars (T11; T12) were more viscous than watermelon nectars (T9; T10). There were no changes ($P > 0.05$) in TSS and consistency in nectar treatments on storage. In their study on juice making from watermelon fruits, Gowda and Jalali (1995) reported no significant changes in consistency on storage for 6 months.

Microbial changes : The fresh watermelon juice had more than 100 cfu/ml and mango pulp had less than 100 cfu/ml. The bottles of unpasteurised watermelon (control) juices resulted in fermentation within 24 h of bottling. Microbial analyses of the nectars by week 5 of storage revealed a minimal presence of microorganisms of 10-100 cfu/ml, thus indicating that the low pH, addition of potassium sorbate (GRAS additive approved in the United States and the West Indies) and pasteurisation were effective in preservation.

Sensory qualities : The sensory overall ranks of the different watermelon nectars are presented in Table 5. There were difference ($P < 0.05$) in overall sensory ranks in colour and appearance in the watermelon treatments. The watermelon/mango nectars (T11; T12) were given the lowest overall ranks and thus were least preferred by panelists, which can be linked to the differences ($P < 0.05$) in sensory colour and appearance scores and 'L' 'a' 'b' values (Table 3). There were no differences

TABLE 5 APPEARANCE (A), COLOUR (C) AND OVERALL (O) SENSORY RANKS FOR WATERMELON NECTARS ON STORAGE

	Storage											
	Week 1			Week 2			Week 3			Week 5		
T No	A	C	O	A	C	O	A	C	O	A	C	O
T9	3.6a	3.1a	3.7a	3.6a	3.7a	3.6a	2.9a	3.2a	3.9a	4.0a	3 9a	3 0b
T10	2.9b	2.6b	3.5a	3.4a	3.0b	3.6a	3.3a	3.5a	3.5a	3.1b	3 3b	3 7a
T11	2.2c	2.3b	2.0b	2.1c	2.2c	2.1b	2.0b	1.6b	2.2b	2.0c	2 5b	2 3c
T12	1.7b	1.5c	1.5c	1.3c	1.6d	2.0b	1.3c	1.2b	1.1c	1.1d	1.0d	1.7d

Mean ranks (# 1 least preferred; #4 most preferred) followed by same letters are not different (P>0.05)
T9 : 100 % watermelon, 25°Brix, 0.15 % citric acid, 0.20 % xanthan
T10 : 100 % watermelon, 20°Brix, 0.15 % citric acid, 0.20 % xanthan
T11 : 85 % watermelon, 15 % mango, 20°Brix, 0.10 % citric acid, 0.20 % xanthan
T12 : 75 % watermelon, 25 % mango, 20°Brix, 0.10 % citric acid, 0.20 % xanthan

($P > 0.05$) in taste. In describing the taste of fruit juices, the Brix-to-acid ratio is commonly used (Potter and Hotchkiss 1995). In these products, the ratios were from 20-25°Brix to 3.75-3.99 (Table 3). Gowda and Jalali (1994) indicated that there was a need to adjust the total soluble solids (TSS) to acidity to improve the ranked acceptability of the watermelon drinks which was also shown in this research.

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RESEARCH NOTE

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Natural Aroma Chemicals as Potato Tuber Sprouting Inhibitor

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The sprouting and rotting of potato during post harvest storage results into tremendous losses. In the present study several naturally occurring volatile essential oils and monoterpenoids were tested as sprout suppressant on potatoes of Cv. 'Kufri Ashoka' stored under ambient conditions (20-38°C, 30-80 % RH) from March to May. Invidividual essential oils of spearmint, peppermint, caraway and dill seed and in mixture peppermint-linalool were found to be most effective sprouting inhibitor, whereas, all the treatments showed no significant differences in rotting behaviour as compared to control, except oils of caraway and dill seed.

Keywords : Sprout inhibition, *Solanum tuberosum* L., Potato, Essential oils, Monoterpenoids.

The potato is a non-cereal crop ranking after wheat, rice and maize in total production. In most of the potato growing regions of India, the crop is harvested at the dawn of the summer during February-March. During storage of potato tubers at ambient conditions (temperature 22-30°C, humidity 50-80 %), sprouting normally occurs at the end of about 6 weeks. Chemical agents have controlled the problem in potato storage to some extent. Commonly used chemicals, as sprout inhibitiors are methyl ester of naphthalene acetic acid, maleic hydride, technazene, propham and chloropropham.

In recent years, there has been a lot of interest to search natural products for the control of sprouting in potato. Application of carvone, pulegone, borneol at 500 mg/kg were effective as sprout suppressants (Beveridge et al. 1981). Plant-derived essential oils, specially the monoterpenoids can be used as an alternative sprout inhibitor (Vaughan and Spencer 1991). Carvone and menthol have been also reported to inhibit sprouting of potato (Ooesterharen et al. 1992, 1995; Capelle et al. 1994, Bouwmeester et al. 1995). Vapour phase treatment of potato tubers with S- (+) carvone fully inhibited bud growth of potato tubers Cv. 'Monalisa' at 23°C (Sorce et al. 1997).

In India, Singh et al (1997) used 13 essential oils and 4 monoterpenoids for sprout inhibition in potato and found that some oils and monoterpenoids inhibited sprouting upto 12 weeks. The present investigation was undertaken to develop indigenous formulation of natural aroma chemicals, which may be more effective and less persistent as compared to synthetic sprout suppressant.

Fully mature and healthy tubers of uniform size of Cv. 'Kufri Ashoka' were obtained from Horticultural Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar.

The aerial parts of the aromatic plant *Mentha arvensis, M. spicata, M. piperita* and *Calistamon lanceolatu* were collected from Central Institute of Medicinal and Aromatic Plants (CIMAP), Pantnagar, and essential oil were extracted by Clavenger distillation.

Small cotton swabs treated with desired concentration of natural aroma chemicals were sandwiched between two cotton pads. The treated cotton pads were placed at the bottom of pre-strelized gunny bags, which were filled with about 1 kg. potatoes and tied and labelled. Treated gunny bags were placed in perforated polythene bags, and stored in a dark room in the first week of March. The treated and control tubers were taken in 3 replicates. The treatment, their concentrations and codes are shown in Table 1. The effect of major constituents of the essential oils tested on fungal growth and sprouting was taken from Vaughan and Spencer (1991).

Observations for sprouting, rotting and loss in weight were taken at the end of experiment, that is 12 weeks after storage, by visual inspection of each tuber and weighing gunny bag.

The response of 'Kufri Ashoka' cultivar of potato to post harvest applications of aroma chemicals on per cent sprouting, rotting and weight loss, after 12 weeks after storage period are shown in Table 2. A perusal of Table 2 indicates that 'Kufri Ashoka' responded differently to various treatments of aroma chemicals.

The sprouting per tuber was recorded as atleast one sprout of 0.5 cm in length. The percent sprouting ranged between 5.6 and 13.3 % in treated tubers, as compared to control, where maximum sprouting (35.75 %) was observed. It is evident from the results that all aroma chemicals either individually or in mixture, except oil of bottlebrush in individual concentration inhibited sprouting significantly as compared to control.

It is interesting to note that mixture of 3 mentha oils with bottle brush oil showed less sprouting than individual bottle brush oil, indicating that 3 mentha oils have some synergistic effect on sprout inhibiting action of bottle brush oil. Similar results were obtained in case of mixture of 3 mentha oils with linalool and linalool alone.

The maximum sprouting (35.75%) observed in control tubers may be due to high humid conditions and low oxygen supply during storage. Recently, Vaughan and Spencer (1991) reported that sprout suppressant activity might be related to volatility of aroma chemicals as well as on the presence of oxygen function in the major constituents of aroma chemicals. They observed that α-pinene and α-phelandrene had less sprout suppressant activity in comparison to 8-cineole, linalool and terpineol, because both hydrocarbons lack oxygen function.

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TABLE 1. DIFFERENT COMBINATION OF AROMA CHEMICALS AND THEIR PHYSICO-CHEMICAL PROPERTIES

Code	Treatment	Dose ml/kg	Major constituents	Activities	
				Fungal growth*	sprouting %
KM-1	*Mentha arvensis*	1.5	Menthol	-	0.0
			Menthone	-	
			Methyl acetate	-	
KM-2	*Mentha spicata*	1.5	Limonene	++	95
			Carvone	-	0.0
KM-3	*Mentha piperita*	1.5	Menthol	-	0.0
			Menthrone	-	
KM-4	*Calistamon lanceolatu*	1.5	α-pinene	+	97
KM-5	*M. arvensis + C. lanceolatu*	0.75			
KM-6	*M. spicata + C. lanceolatu*	0.75			
KM-7	*M. piperita + C. lanceolatu*	0.75			
KM-8	*M. arvensis + Linalool*	0.75			
KM-9	*M. spicata +Linalool*	0.75			
KM-10	*M. piperita + Linalool*	0.75			
KM-11	*Linalool*	1.5	Linalool	-	0.0
KM-12	*Carum carvi*	1.5	Limonene,	++	95
			Carvone	-	0.0
KM-13	*Anethum graveolens*	1.5	Limonene,	++	95
			Carvone	-	0.0
KM-15	Control				

* Visual ratings as follows : - = No fungal growth, ++ = Heavy fungal growth

TABLE 2. SPROUT INHIBITION, ROTTING AND WEIGHT LOSS OF POTATO TUBERS EXPOSED TO NATURAL AROMA CHEMICALS DURING STORAGE FOR 12 WEEKS.

Treatments	Percent tubers sprouted	Percent rotting	Percent weight loss
KM-1	10.4	28.90	19.55
KM-2	6.4	22.70	14.45
KM-3	7.19	23.75	15.08
KM-4	13.36	21.05	19.66
KM-5	6.7	20.00	18.27
KM-6	11.6	31.41	19.75
KM-7	5.6	16.90	14.61
KM-8	7.19	12.63	18.39
KM-9	6.25	14.25	17.94
KM-10	10.6	8.45	22.31
KM-11	12.4	22.95	13.43
KM-12	11.2	8.54	21.17
KM-13	9.5	10.45	19.21
KM-15	35.75	22.40	23.03
CD at 5%	3.1127	5.0941	4.0304

The minimum sprouting in potato tuber treaks with oils of caraway, dill seed, spearmint, japanesemint and pippermint may be due to the presence of oxygen in major constituents of these oils i.e. carvone in caraway, dill seed and spearmint and menthone and menthol in japanesemint and pippermint oil (Table 1).

The rotting ranged from 8.45 to 31.41% in treated tubers as compared to control (22.4 %). From Table 2, it is clear that in case of individual oils only caraway and dill seed oils showed significantly less rotting than control and in case of mixture of 3 mentha oils with linalool showed less rotting than control. All other treatments showed no significant difference in rotting behaviour as compared to control.

During storage, the rotting in potato was mainly caused by microbial growth, which may be directly related to high temperature, dampness and humidity during storage. These factors are responsible for depletion of oxygen thus favouring growth of microbes. Oils of caraway and dill seed contain limonene as a major constituent, which has been reported to possess antifungal activity (Singh and Upadhyay 1993). Similarly, mixture of 3 mentha oils with linalool showed less rotting due to presence of active constituents like menthol, menthone, limonene and linalool as antifungal agents (Singh and Upadhyay 1993). Less rotting in treatments of 3 mentha oils with linalool indicated that these had some sort of joint action, as these oils and linalool in individual treatment showed no significant difference in rotting behaviour than control.

After 12 weeks of storage, the tubers responded differently to various treatments, which resulted in weight loss ranging from 13.43 to 22.31% as compared to control (23.03%). Spearmint and pippermint oil and linalool in individual treatment showed significantly less weight loss than control, while in mixtures of linalool with spearmint and japanesemint as well as mixtures of bottle brush oil with japanesemint and pippermint oils also showed significant difference in weight loss than control.

Loss in weight of potato tubers during storage may be due to metabolic changes and vital functions such as

evaporation, respiration and sprouting. Initially, weight loss was more due to loosening of skin from flesh, whereas after a month of storage, the skin was covered with cork layer, which retarded evaporation. Besides this, weight loss also occurred due to rapid evaporation of water from the tubers during sprouting and high temperature, microbial growth and respiration. Thus, the weight loss in potato during storage of 'Kufri Ashoka' cultivar might be due to the aforesaid factors.

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Effect of Incorporation of Defatted Soyflour on the Quality of Sweet Biscuits

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Replacement of wheat flour up to 40 % level with defatted soyflour in the standard sweet biscuits recipe increased the protein content from 6.5 to 14.8 %, bending hardness from 3.60 to 9.85 N. and cutting hardness from 6.02 to 23.04 N of the biscuits. Sensory evaluation results showed that all of the biscuits from various blends were acceptable with no significant differences among them.

Keywords : Defatted soyflour, Sweet biscuits, Bending hardness, Sensory evaluation.

Biscuits are very convenient and inexpensive food products and are becoming very popular among both rural and urban population of India. These baked products have about 6-7 % proteins. There is an ever growing demand for high protein biscuits for therapeutic value. They can be considered for Applied Nutrition Programs in India (Agrawal 1990). The enrichment of protein may be achieved through incorporation of protein-rich ingredients. (McWatters 1978; Dubois and Hoover 1981). Among them defatted soyflour has a great potential due to its high and good quality protein (50-52 %) at affordable cost. Besides its nutritive value, it may improve the functional properties of the dough. The present work was undertaken to study the effect of defatted soyflour on the nutritional profile and textural properties of sweet biscuits.

Raw material : Soybean (variety 'JS 7635') with a moisture content of 11 % was procured from the Farm Section of the Institute. After cleaning, soyflakes were prepared using the method developed at this Institute (Patil et al. 1990). The flakes were used for solvent extraction using traditional Soxhlet apparatus. The meal contained 7.8 % moisture, 51% protein, 0.2 % fat, 5.3 % ash, < 20 ppm n-hexane and 35 NSI.

Preparation of sweet biscuits: The standard formula for sweet biscuit preparation has the ingredients like 200 g refined wheat flour, 80 g hydrogenated vegetable fat, 2 g baking powder, 1.6 g baking soda, 2 g salt and required amount of water. Biscuits were prepared from the blends containing 10 %, 20%, 30 %, and 40 % defatted soyflour using the traditional creamery method (Whiteley 1970). All these ingredients were purchased from the local market.

Proximate composition : The samples were analysed for moisture, crude protein, crude fat, total carbohydrates and ash using AOAC (1989) methods. Triplicate samples were used and the average values were expressed on as is basis. All the chemicals were of analytical grade.

Textural analysis : Texture Analyzer TA-Xt/2i was used to measure the bending hardness/cutting hardness. The conditions for hardness measurement of biscuits by cutting were: pretest speed 3 mm/s, test speed 3 mm/s, post test speed 10 mm/s, distance 5 mm, trigger type 20 g and data acquisition rate 200 pps. Knife edge with slotted insert (HDE/BS) blade set and 25 kg load cell were used. The samples were halved and placed centrally under knife edge. The conditions for hardness measurement of biscuits by bending/snap test were: pretest speed 2 mm/s, test speed 0.5 mm/s, post test speed 10 mm/s, distance 5 mm, trigger auto 20 g, data acquisition rate 400 pps and three point bending ring (HDP/3PB) with 25 kg load cell. The bending hardness is the maximum force that these biscuits bear before they break and expressed in Newton (N).

Sensory evaluation : The sensory attributes like taste, colour, appearance, texture and overall acceptability were determined using an informal taste panel consisting of 10 untrained panelists. The ratings were on a 9 point Hedonic scale ranging from 9 (like extremely) to 1 (dislike extremely). Results were subjected to Analysis of Variance.

The data (Table 1) show that the protein and ash contents increased from 6.5 to 14.8 and 4.2 to 5.0 % respectively with increasing the defatted soyflour in the blend from 0 to 40 %. The fat and carbohydrate contents decreased from 26 to 21 % and 61.5 to 55.2 %, respectively with the incorporation of defatted soyflour. The moisture content of these biscuits varied from 1.7 to 4.9 %. Similar results in soyfortified chapatis have been reported (Gandhi et al. 1983; Gandhi and Bourne 1988). Effect of incorporation of defatted soyflour on the texture of biscuits is presented in Table 2. The results indicated an increase in bending hardness from 3.60 to 9.85 N and the cutting hardness from 6.02 to 23.0 N.

TABLE 1. COMPOSITION OF DEFATTED SOYFORTIFIED BISCUITS

Nutrients	Defatted soyflour, %				
	0	10	20	30	40
Crude protein, (N x 6.25), %	6.5	10.0	11.2	12.2	14.8
Crude fat, %	26.0	25.0	23.0	22.0	21.0
Total carbohydrates, %	61.5	58.9	57.4	56.1	55.2
Ash, %	4.2	4.4	4.6	4.8	5.0

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TABLE 2. BENDING AND CUTTING HARDNESS OF THE BISCUITS

Treatment	Hardness (Force, N)	
	Bending	Cutting
Control	3.60	6.02
10 % DFSF	4.27	10.50
20 % DFSF	5.31	18.46
30 % DFSF	7.46	20.02
40 % DFSF	9.85	23.04

DFSF : Defatted soyflour

TABLE 3. MEAN SCORES OF SENSORY CHARACTERISTICS OF DEFATTED SOY BISCUITS

Sample	Mean scores					
	Colour	Appear-ance	Flavour	Texture	Taste	Overall accept-ability
DFSF, 10 %	7.1	7.1	6.3	6.9	7.3	7.4
DFSF, 20 %	6.4	6.9	6.1	6.4	7.5	6.8
DFSF, 30 %	6.9	6.7	6.9	7.0	7.1	7.0
DFSF, 40 %	6.9	7.0	6.6	7.5	8.0	7.3

DFSF : Defatted soyflour

TABLE 4. ANALYSIS OF VARIANCE OF TASTE PANEL SCORES FOR THE CHARACTERISTICS OF DIFFERENT DEFATTED SOY BISCUITS

Source of variation	DF	Mean sum of squares					
		Colour	Appear-ance	Flavour	Texture	Taste	Overall accept-ability
Products	3	0.89**	0.29**	1.5*	2.09*	0.29**	0.75**
Judges	9	3.11**	3.33**	3.98**	3.58**	3.58**	0.73**
Error	27	0.558	0.336	0.476	0.536	0.55	0.499

*Significant at 5 % level of significance
** Non significant at 5 % level of significance

Increase in hardness is due to the increase in protein content and decrease in fat and carbohydrates. The mean score values for different sensory characters are presented in Table 3. The scores were assigned in comparison with control biscuits (score of nine). The mean scores for all the characters and overall acceptability was more than the minimum acceptable score of five. A separate analysis of variance was done for each character namely, taste, appearance, flavour, texture, taste and overall acceptability from every individual score of taste panel. This analysis was carried out to find out the differences among the characteristics and panelists. The results are shown in Table 4. The results indicate that the difference among the treatments is significant for flavour and texture and non significant for colour, appearance, taste and overall acceptability at 5 % level of significance. The disagreement among the judges for all these characteristics was not significant at 5 % level of significance. Thus, the data reveal that the source of variance among the products is only due to characteristics like flavour and texture and the variance due to judges does not exist.

Conclusion

Acceptable quality high protein biscuits could be produced by replacing wheat flour up to 40 % defatted soyflour.

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Effect of Pre-treatment on Drying Characteristics and Colour of Dehydrated Green Chillis

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Effect of selected pre-treatments on drying characteristics and colour of green chilli (*Capsicum annuum*) was investigated. Blanching was carried out in hot water at 95°C for 5 min. The pre-treatments were: blanching followed by dipping for 15 min at room temperature in (i) cold water, control, (T1); 1000 ppm sulfur dioxide solution (T2); 1 % lye solution (T3); 1 % lye solution containing copper sulphate and magnesium sulphate each at 500 ppm (T4); and 1 % lye solution containing 0.25 % magnesium carbonate (T5) respectively. Pre-treatments resulted in increasing the drying rate, while pre-treating blanched chillis in 1 % lye solution containing 0.25 % magnesium carbonate (T5) retained maximum colour of the product (in terms of Hunter colour-'a' value). The drying kinetics revealed that for the entire duration, drying took place under the falling rate period and Page's model fitted well the drying behaviour of green chilli.

Keywords : Green chillis, Pre-treatment, Drying, Falling rate period, Colour, Hunter colour *a* value.

Chillis (*Capsicum annuum*) are the most widely used spices all over the world. Chillis are the fruits of the capsicum plant and may vary in shape, size, colour and pungency. Both red and green chillis can be used as fresh but dried chillis are also used extensively. Green chillis have a delicious capsicum flavour in addition to the hotness, which adds zest to various food preparations. The fresh fruit is also used in salads, pickles and canned products (Govindarajan et al. 1987). Annual trade of chilli in the world is 0.055-0.065 MT, which is 16.7 % of total spice trade in the world (Peter 1994). India ranks first in the production (0.691 MT) as well as in the export (0.033 MT) of chilli in the world.

The retention of naturally coloured pigments in thermally processed and stored foods has been a major challenge in food processing, Several attempts have been made to stabilize the colour but with limited success (Ihl et al. 1998). The most common change that occurs during thermal processing of green vegetables and spices is the conversion of chlorophyll to pheophytins, causing a change from bright green to olive-brown (Rocha et al. 1993; Ihl et al. 1998). Generally, the acetone-extracted chlorophyll is measured spectrophotometrically which is time consuming and thermally decomposed pheophytins interfere in its measurements (Eheart and Gott 1965). Alternatively, colour, which is an indicator of cholorophyll content, can be measured instantaneously for on-line quality control (Rocha et al. 1993). Hunter colour parameters *L*, *a* and *b* have been widely used to describe the colour change during heat processing of fruit and vegetable products by several research workers (Lukes 1986; Rocha et al. 1993; Shin and Bhowmik 1994; Ahmed et al. 2000 a, b; Ahmed et al. 2001).

As far as preservation of vegetables is concerned, drying is the most widely used method for reducing the water activity and microbial infection. The characteristic colour of the dried green chilli is considered as one of the essential quality indicator. Non-enzymatic browning and chlorophyll losses during drying contribute substantially to colour loss in green chilli. Luhadiya and Kulkarni (1978) investigated the effect of pre-treatment and hot air drying on chlorophyll retention and rehydration characteristics of green chilli. They reported that the pre-treatment with 2 % lye solution, washing and drying at 60°C gave the best product. Drying kinetics parameters are very important for dryer simulation and design. In this regard information on green chilli and the effect of pre-treatment on its drying kinetics and on green colour are lacking. The present study was, therefore, undertaken to minimize colour loss by adequate pre-treatments and to investigate drying kinetics of green chilli.

Green chilli variety 'CH-1' was procured locally, washed in running water to remove the adhering impurities and destalked manually. Blanching was done at 95°C for 5 min using hot water followed by dipping in different solutions to pre-treat chilli before drying (Table 1). Pre-treated chilli (2 kg batch each) was spread on a perforated tray and dried in a cabinet dryer at 60°C with a tray load of 4.5 kg/m^2. The drying was carried out to a final moisture content of 10 % from an initial moisture content of about 650 % (dry basis). Moisture content of chilli was determined by drying the sample in a

TABLE 1. DETAILS ON PRE-TREATMENT OF GREEN CHILLI

Treatment	Details
T1	Blanching in hot water at 95°C for 5 min followed by dipping in water for 15 min at room temperature. Considered as the control.
T2	Blanching in hot water at 95°C for 5 min followed by dipping in 1000 ppm KMS solution for 15 min at room temperature.
T3	Blanching in hot water at 95°C for 5 min followed by dipping in 1 % NaOH solution for 15 min at room temperature.
T4	Blanching in hot water at 95°C for 5 min followed by dipping in 1 % NaOH solution + 500 ppm copper sulfate + 500 ppm ferrous sulfate for 15 min at room temperature.
T5	Blanching in hot water at 95°C for 5 min followed by dipping in 1 % NaOH solution + 0.25 % magnesium carbonate for 15 min at room temperature

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vacuum oven, till it attained a constant weight (AOAC 1990) and the values were expressed in % (dry basis). Equilibrium moisture content of the dried product was determined by the static method (Rahman 1995).

Colour measurement : Colour was measured by Hunter Colour Difference Meter (D25 DP-9000 system, Hunter Associates Laboratory Inc., Reston, VA, USA). About 200 g dried green chilli powder passed through 40 mesh screen, was tightly filled in a standard optical cell having 6-cm diameter for the measurement. The instrument was calibrated with a fresh ground green chilli sample as standard ($L = 29.12$, $a = -4.91$ and $b = 14.75$) under illuminated conditions. The information given by *L, a* and *b* generally expressed as total colour of prepared paste. *L* represents the lightness index (0 for black to 100 for white), *a* represents greenness and redness (+ 100 for red and - 80 for green) while *b* represents for yellowness and blueness (+ 70 for yellow and - 80 for blue).

Drying characteristics : Following the work of Luhadiya and Kulkarni (1978), chillis was dried at 60°C. The drying rates were computed using a numerical differentiation technique. The Lagrangian differentiation technique (O'Neil 1983) using three data points was used to calculate the drying rate. A typical drying rate curve, while chillis were pre-treated in hot water at 95°C for 5 min, followed by dipping in 1 % lye solution containing 0.25 % magnesium carbonate for 15 min (T5) and dried at 60°C is shown in Fig. 1. Constant rate period was not present and for the entire duration drying of green chillis took place under the falling rate period. Drying of chillis may, therefore, be postulated as a diffusion-controlled process and may be represented by Fick's law of diffusion. Various types of mathematical models have been used to describe drying of food materials; ranging from theoretical models based on classical diffusion theory and simplified form of these, to purely empirical models (Byler et al. 1987). One equation that has been widely used to describe drying behaviour of variety of biological materials (Hutchinson and Otten 1983; Byler et al. 1987) is the Page's equation,

$$MR = \exp(-kt^n) \quad \ldots\ldots (1)$$

where, MR = moisture ratio, dimensionless

$$MR = (m-m_e)/(m_o-m_e) \quad \ldots\ldots (2)$$

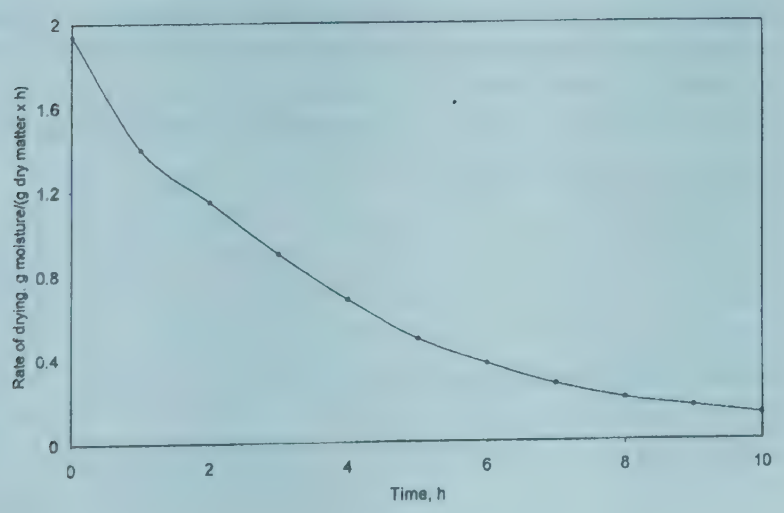

Fig. 1. Drying rate curve for green chilli at 60°C

m - moisture content at any given instant t, % (dry basis)

m_o - initial moisture content, % (dry basis)

m_e - equlibrium moisture content, % (dry basis)

t - time, h

k - coefficient, also called the rate constant, per h

n - coefficient, dimensionless

Equation (1) may be linearliized as :

$$1n [- 1n (MR)] = 1n (k) + n\ 1n (t) \quad \ldots\ldots (3)$$

Equilibrium moisture content of green chilli at drying air condition (60°C and 15 % relative humidity) was found be 7.5 % (dry basis). Linear regression of equation (3) was carried out using the least square's technique and the coefficients were determined. The values of the coefficients are given in Table 2. A typical drying behaviour of green chilli, pre-treated at 95°C for 5 min followed by dipping in solution containing 1 % lye and 0.25 % magnesium carbonate (T5), is shown in Fig. 2. As seen in Fig. 2, the Page's model fitted adequately the hot air drying of green chilli; the solid lines represent equation (3). The coefficients of determination values were greater than 0.973 while standard error values were less than 0.072 in all cases.

Pre-treatments, in general, resulted in enhancing the drying rate as indicated by greater values of the rate constant, k. Difference in k values among the pre-treatments was not substantial however. Variation of n with pre-treatment was not systematic.

Colour : Hunter colour -*a* value, a measure of greenness, was -4.91 for fresh chilli. Effect of selected pre-treatments on the Hunter colour values of the dried green chillies is shown

TABLE 2. VALUES OF THE COEFFICIENT OF PAGE EQUATION

Pre-treatment	k, (1/h)	n, dimen-sionless	R^2	SE
T1, Control	0.202	1.154	0.984	0.056
T2	0.244	1.216	0.994	0.038
T3	0.240	1.135	0.973	0.072
T4	0.252	1.123	0.991	0.044
T5	0.244	1.042	0.987	0.041

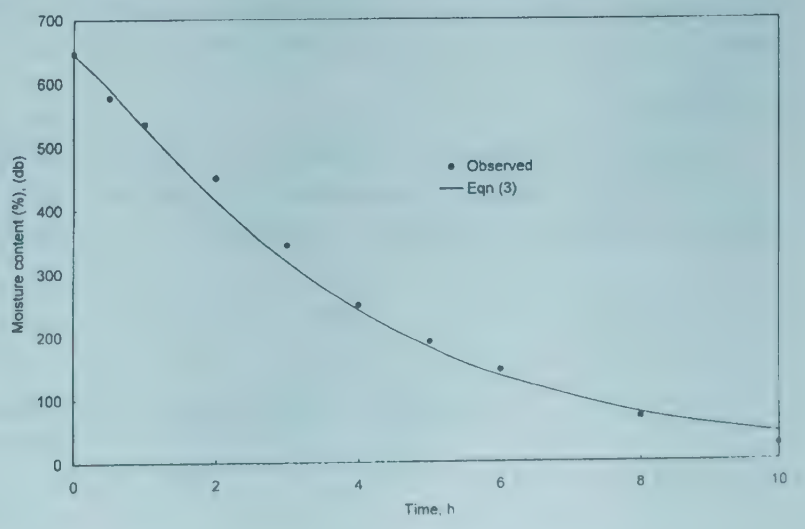

Fig. 2. Drying characteristics of green chilli at 60°C

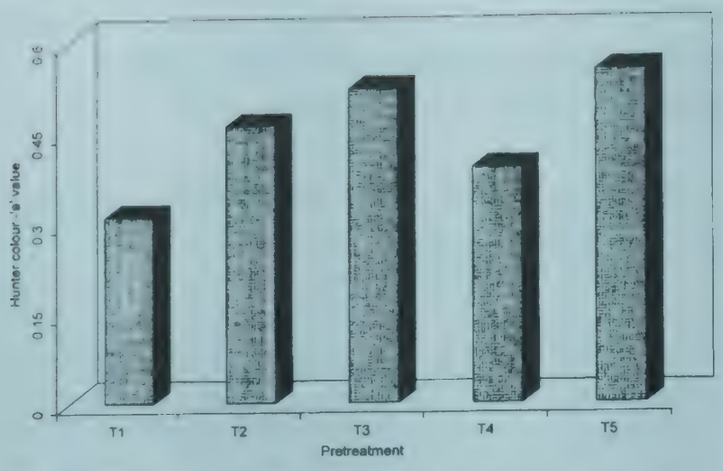

Fig. 3. Effect of pre-treatment on Hunter colour 'a' value

in Fig. 3. Drying of chillis in hot air reduced considerably green colour of chillis as reflected by reduced - *a* values for the dried product. Among the various pre-treatments, blanching in hot water at 95°C for 5 min followed by dipping in solution containing 1 % lye and 0.25 % magnesium carbonate for 15 min at room temperature (T5) resulted in minimum loss of green colour (*a* = -0.55). This observation is in agreement with that of Clydesdale et al (1968) who found that blanching of spinach in a solution of $MgCO_3$ increased the formation of chlorophyllides and decreased the conversion of both chlorophyll and chlorophyllides into pheophytins and pheophorbides, respectively. Luhadiya and Kulkarni (1978) reported that chlorophyll retention was maximum while blanched chillis were pre-treated in 2 % lye solution for 10 min. Preliminary trials indicated excessive loss of green pigment for 2 % lye treatment; lye concentration was therefore kept at 1 % during the present study.

Hot water blanching alone (T1) followed by hot air drying at 60°C produced a pale green product (*a* = - 0.31) since the heat labile chlorophyll degraded to pheophytin: a and b due to loss of magnesium ion (Mg^{++}). Similar observation was reported by Rocha et al. (1993) while studying the dehydration of basil. Blanching in 1 % lye solution (T3) followed by drying retained more chlorophyll (*a* = - 0.46) than water blanching (T1). At normal pH, the green pigment loss was more while the pigment retention increased with sulphitation (T2). Improvement in colour (*a* = - 0.39) was not substantial while $FeSO_4$ and $CuSO_4$ were added during pre-treatment (T4).

Conclusion

Blanching in hot water at 95°C for 5 min followed by dipping chillis in solution containing 1 % lye and 0.25 % magnesium carbonate at room temperature for 15 min and drying at 60°C resulted in retaining maximum green colour in the dried product. Drying took place under the falling rate period and Page's equation fitted adequately the drying behaviour of green chillis.

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RESEARCH NOTE

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Effect of Supplementation of Processed Maize Germ Cake on Nutritional Quality of Maize

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Processed defatted (deoiled) maize germ cake (PDMGC) was analysed for its proteins and the lysine and tryptophan contents. These values were found to be 23.90 %, 4.92 g/16 g N and 1.20 g/16 g N respectively. Addition of PDMGC to normal maize in the ratio of 1:1 on protein basis, improved the biological value (BV), net protein utilization (NPU), utilizable nitrogen (UN) and feed efficiency ratio (FER) by 18.2, 11.4, 60.6 and 20.0 % respectively. However, there was only a slight decrease (6.5 %) in true digestibility (TD).

Keywords : Processed defatted maize germ cake, Biological value, True digestibility, Net protein utilization, Utilizable nitrogen, Feed efficiency ratio.

Maize germ is value-added food product due to its higher nutritional value. In both dry and wet milling process of maize, the germ is separated from the kernel and used for oil extraction (Brekke 1970; Anderson 1970). The extracted oil under the trade name "CORNOLA" is used for human consumption and the resultant fresh cake is used as animal feed and as fertilizer. In wet milling of high lysine corn, the germ is obtained as value-added food product (Bressani 1966; Clark 1986). Being a rich source of good quality protein (Gupta and Eggum 1998), there is a wide scope for maize germ cake to be used in various food products for human consumption after removing undesirable materials like residual fat, pigments and fibrous materials which are nearly 13 % on dry basis. Therefore, in the present investigation, protein quality of maize with supplementation of PDMGC in the ratio of 1:1 on protein basis was evaluated and compared with normal maize without supplementation.

Processed defatted maize germ cake (PDMGC) and a common maize variety "Ganga-5" were used in the present study. "Ganga-5" was grown on the Institute farm under identical agronomical conditions. Fresh commercial maize germ cake was obtained from a starch industry, Yamuna Nagar-Haryana and processed according Gupta and Eggum (1998).

Proteins (% N x 6.25), fat, ash and crude fibre (CF) contents were determined according to standard methods of AOAC (1975), while starch was determined using anthrone reagent as described by Clegg (1956) and Hedge and Hofreiter (1962). Lysine and tryptophan were estimated by colorimetric methods according to Villegas and Mertz (1971) and Hernandez and Bates (1969), respectively.

Isonitrogenous diets were prepared according to the procedure described by Eggum (1973) and PDMGC was supplemented in the maize in the ratio of 1:1 on protein basis. Nitrogen balance of each of the diets was determined using five growing male Wistar rats weighing 60 ± 0.5 g per group by the method of Mitchell and Carman (1926) in a room maintained at 24 ± 1°C temperature with 60 % humidity as described by Eggum (1973). Each rat received 10 g dry matter containing 150 mg of N daily.

A comparative data of chemical composition, lysine and tryptophan contents of "Ganga-5" maize and PDMGC are given in Table 1. In PDMGC, protein, ash and crude fibre were much higher and starch content was much lower than that of common maize but it was still higher than that of pure maize germ (Gupta et al. 1984). This was due to incomplete separation of the endosperm and pericarp during processing of bran which adhered to the germ and endosperm so tightly that even after going through a pair of rollers, they held together (Wichser 1966). Lysine and tryptophan, the limiting amino acids in maize, were higher in PDMGC than those of normal maize and could meet the requirements of preschool children i.e., 5.5 and 1.0 g/16 g N respectively (FAO/WHO 1973). However, there was no significant difference between the fat contents.

Biological value (BV), net protein utilization (NPU), utilizable nitrogen (UN) and feed efficiency ratio (FER), which were lower in "Ganga 5" maize than those of PDMGC, improved after supplementation with PDMGC in the ratio of 1:1 on protein basis (Table 2). These improvements were 18.2, 11.4, 60.6 and 20.0 % in BV, NPU, UN and FER, respectively. In the case of true digestibility (TD), which was higher in

TABLE 1. CHEMICAL COMPOSITION, LYSINE AND TRYPTOPHAN CONTENT IN PDMGC[a], GERM AND MAIZE[b]

Parameters	Normal maize	PDMGC	Germ[c]	Suggested level for preschool children[d]
Protein, %	12.63	23.94	23.41	-
Fat, %	4.60	4.34	34.19	-
Ash, %	1.55	4.60	5.68	-
Starch, %	69.97	33.11	8.30[d]	-
Crude fibre, %	2.60	4.10	7.24	-
Lysine, g/16 g N	2.89	4.90	5.43	5.5
Tryptophan, g/16g N	0.68	1.15	0.77	1.0

[a]Processed defatted maize germ cake
[b]Average value of duplicate analysis
[c]Gupta et al. 1984
[d]FAO/WHO, 1973

TABLE 2. EFFECT OF PDMGC SUPPLEMENTATION ON MAIZE QUALITY IN RATS

Products	True digestibility	Biological value	Net protein utilisation	Utilizable nitrogen[a]	Feed efficiency ratio[c]
Normal maize	90.20 ± 1.31	59.99 ± 4.96	53.86 ± 3.76	1.09 ± 0.08	0.045 ± 0.01
Normal maize + PDMGC[c]	84.30 ± 1.10	70.89 ± 2.55	59.99 ± 2.89	1.75 ± 0.12	0.054 ± 0.02
PDMGC	87.80 ± 0.67	88.89 ± 0.96	78.05 ± 0.79	2.98 ± 0.04	0.170 ± 0.01
CD at 5 %	4.5	12.90	11.61	0.31	0.20
SEM	1.37	3.96	3.56	0.09	0.05

[a]Net protein utilization x protein (% of dry matter)/100; [b]Weight gain/feed consumed over 9 days period; [c]Mixed in the ratio of 1:1 on protein basis

"Ganga 5" maize than that of PDMGC, decreased by 6.5 % after supplementation with PDMGC.

The present investigation has shown that PDMGC contains about 24.0 % of good quality protein in which, level of lysine and tryptophan are very high and would meet the requirements of preschool children (FAO/WHO 1973). It has also very high BV, which is comparable to casein (Gupta et al. 1979). In their earlier studies, Gupta and Eggum (1998) also reported values of 4.97 and 1.19 g/16 g N for lysine, tryptophan, respectively and 89.10 BV for PDMGC. Its supplementation in the ratio of 1:1 on protein basis improves the BV, NPU, UN and FER whereas TD decreases slightly. This is due to high CF content in PDMGC.

From these observations, it has been confirmed that supplementation of PDMGC which is a new cheap source of good quality protein, can be used to improve the protein quality of any cereal or its food products as it contains all the essential amino acids in sufficient quantities (Gupta and Eggum 1998). Recently, biscuits of wheat and maize have been prepared with and without supplementation of PDMGC and these are well accepted. Therefore, it may be concluded that its utilization will help consumers to get good quality foods at cheaper rates.

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RESEARCH NOTE

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Effect of Moisture Content, Temperature and Contact Time on Milling and Cooking Qualities of Rice in Conduction Parboiling

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Milling and cooking qualities of conduction parboiled paddy samples of 'ADT 36', 'IR 20' and 'CO 45' were determined. The initial moisture content and contact time contributed for more head rice recovery, alkali expansion value and gelatinization percentage. Hardness increased by 50 to 60 %, whereas the whiteness decreased due to parboiling compared to that of control. The cooking time decreased by 1 to 2 min. and there was no appreciable change in water uptake and swelling index.

Keywords : Paddy, Conduction parboiling, Head rice recovery, Cooking qualities.

The conduction parboiling has the unique feature in that parboiling and drying of paddy are done simultaneously, thereby reducing the energy requirement. To achieve uniform parboiling, each grain should be heated to the required temperature and time and at the same time, heat treatment given should be mild to avoid any quality changes. Many research works have been carried out to optimise the temperature of the contacting medium with paddy (IRRI 1970). However, the influence of initial moisture content and contact time on the milling and cooking qualities of the conduction parboiled rice have not been investigated.

Three ruling paddy varieties viz., 'ADT 36', 'IR 20' and 'CO 45' were selected for the study. The samples of the paddy were hot-soaked at 70°C to obtain the initial moisture contents of 28, 30 and 32 % on wet basis. The soaked paddy was parboiled in sand in the conduction parboiling unit (Varadharaju and Sreenarayanan 1998), which was maintained at 140°C. The conduction parboiling unit consists of a rotating drum with sieve, oil circulating system, feed hopper, temperature controlling devices, reduction gear box and a motor. The annular drum has a screw auger in the inner surface to convey the paddy and sand mixture from the inlet to the outlet. At the outer surface of the drum a left handed screw auger is provided to pass the sand back to the inlet. During the operation, sand in the drum is heated to the required temperature and the soaked paddy is mixed with hot sand for a particular time and is separated by means of sieve.

The parboiling was carried out for different contact times of 30, 45, 60 and 75 sec. The parboiled paddy was dried in a mechanical drier at 70°C. The shelling and polishing of paddy were done as per BIS (1990) in McGill sheller and McGill miller No. 2, respectively. The alkali expansion value (Mohandoss and Pillaiyar 1980) gelatinization percentage (Bandopadhyay and Roy 1977), cooking time (Ranghino 1966), water uptake (Patil et al. 1982) and swelling index (Kurien et al. 1964) were determined for the milled rice and compared with control. The whiteness of rice sample was measured using Satake milling meter model MM-1B and that of hardness with KIYA hardness tester. The paddy samples parboiled as per CFTRI (1960) procedure was taken as control.

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The influence of variety, initial moisture content and contact time on head rice recovery of parboiled paddy are presented in Table 1, which showed that the head rice recovery increased with contact times for all the three varieties.

Head rice recovery : At the low initial moisture level of 28 %, the head rice recoveries of 'ADT 36' varied significantly for all the contact times. In 'IR 20' and 'CO 45' varieties, the head rice recoveries at 60 and 75 sec were on par. However, they differed significantly at lower contact times of 30 and 45 sec. At 30 % initial moisture content, all the three varieties recorded the maximum of 100 % head rice recovery at 75 sec contact time. Head rice recoveries of 'ADT 36' and 'IR 20' at a contact time of 60 sec were on par with 75 sec contact time, but in 'CO 45' these differed significantly. At 32 % initial moisture content, the head rice recoveries of all three varieties at 60 and 75 sec were on par. Head rice recovery differed significantly between contact times of 30 and 45 sec.

Alkali expansion value : The alkali expansion value generally increased with contact time at all moisture contents (Table 1). For the 'ADT 36' variety at the 30 % moisture content and contact time of 60 sec, the alkali expansion value was comparable (187.5) with that of control (185.5). Regarding 'IR 20' and 'CO 45' varieties, the lower moisture content of 28 % with 60 sec contact time had the alkali expansion values comparable to that of control. At initial moisture content of 32 % at 45 sec contact time, for all the three varieties, the alkali expansion values were comparable to those of control. The higher alkali values at a contact time of 75 sec in all moisture contents clearly showed that the samples had been severely parboiled and this was not a desirable quality.

Gelatinization percentage : At all initial moisture contents the gelatinization percentage increased with increase of contact time (Table 1). In 28 % initial moisture content, the complete gelatinization was observed at a contact, time of 75 sec in 'ADT 36' variety. The maximum gelatinization percentage (100 %) was obtained at 60 sec contact time itself in the case of 'IR 20' and 'CO 45' varieties at the same initial moisture. At 30 % initial moisture content, the gelatinization percentage was maximum (100 %) for all varieties, when the contact time was 60 sec. There was significant difference in gelatinization percentage at lesser contact time for all the three varieties.

TABLE 1. EFFECT OF INITIAL MOISTURE CONTENT AND CONTACT TIME ON HEAD RICE YIELD, GELATINIZATION AND ALKALI EXPANSION VALUE OF CONDUCTION PARBOILED PADDY

Initial moisture content, % w,b.	Contact time, sec	Head rice recovery				Alkali expansion value				Gelatinization percentage			
		'ADT 36'	'IR 20'	'CO 45'	T Mean	'ADT 36'	'IR 20'	'CO 45'	T Mean	'ADT 36'	'IR 20'	'CO 45'	T Mean
28	30	78.37^{d}	81.43^{c}	81.17^{c}	80.32	33.67^{d}	44.67^{d}	40.67^{d}	39.67	18.83^{d}	26.67^{c}	26.83^{c}	24.11
	45	87.32^{c}	88.73^{b}	86.80^{b}	87.62	85.83^{c}	103.83^{c}	91.50^{c}	93.72	56.00^{c}	65.50^{d}	70.33^{b}	63.94
	60	95.92^{b}	99.47^{a}	99.08^{a}	98.16	164.00^{b}	182.83^{b}	196.83^{b}	181.22	79.00^{b}	100.00^{a}	100.00^{a}	93.00
	75	99.68^{a}	99.76^{a}	99.47^{a}	99.63	271.17^{a}	289.00^{a}	279.33^{a}	279.83	100.00^{a}	100.00^{a}	100.00^{a}	100.00
30	30	85.46^{d}	85.46^{d}	83.07^{d}	83.58	44.50^{d}	66.33^{d}	69.00^{d}	59.94	30.67^{c}	37.83^{c}	39.67^{c}	36.06
	45	93.93^{b}	93.93^{b}	94.60^{c}	93.14	129.67^{c}	141.33^{c}	154.17^{c}	141.72	76.33^{b}	88.33^{b}	92.33^{b}	86.67
	60	99.63^{a}	99.63^{a}	99.43^{b}	99.28	187.50^{b}	241.17^{b}	252.67^{b}	227.11	100.00^{a}	100.00^{a}	100.00^{a}	100.00
	75	100.00^{a}	100.00^{a}	100.00^{a}	100.00	306.83^{a}	329.00^{a}	331.50^{a}	322.44	100.00^{a}	100.00^{a}	100.00^{a}	100.00
32	30	85.03^{c}	86.73^{c}	83.98^{c}	85.25	62.33^{d}	74.33^{d}	79.83^{d}	72.17	36.33^{c}	45.33^{b}	50.50^{b}	44.06
	45	94.42^{b}	98.65^{b}	98.80^{b}	97.28	177.17^{c}	167.67^{c}	174.67^{c}	173.17	91.17^{b}	100.00^{a}	100.00^{a}	97.06
	60	95.51^{a}	99.61^{a}	99.66^{a}	99.59	230.67^{b}	312.00^{b}	314.83^{b}	285.83	100.00^{a}	100.00^{a}	100.00^{a}	100.00
	75	100.00^{a}	100.00^{a}	100.00^{a}	100.00	348.50^{a}	413.33^{a}	394.50^{a}	385.44	100.00^{a}	100.00^{a}	100.00^{a}	100.00
Mean		92.67	94.45	93.83		170.15	197.13	198.29		74.03	80.31	81.64	
		SEd	LSD (5 %)	LSD (1 %)		SEd	LSD (5 %)	LSD (1 %)		SEd	LSD (5 %)	LSD (1 %)	
t x M x v mean		0.82	1.63	2.15		7.63	15.08	19.91		0.82	1.63	2.15	

The gelatinization percentage was found to be maximum (100 %) at 45 sec itself with 32 % initial moisture content for varieties 'IR 20' and 'CO 45' whereas in 'ADT 36', it was 100 % only at 60 sec. The gelatinization percentage was only 50.5 % for 'CO 45' followed by 45.33 % and 36.33 % for 'IR 20' and 'ADT 36', respectively at the higher initial moisture content of 32 % with 30 sec contact time. This might have been due to insufficient temperature required for the complete gelatinization of starch at lower contact time (Bandyopadhyay and Roy 1977).

From the above results, it was concluded that 30 % initial moisture content and a contact time of 60 sec was the best combination for 'ADT 36' whereas for 'IR 20' and 'CO 45' initial moisture content of 28 % was sufficient with a contact time of 60 sec to get optimum parboiling. For the above treatment, the quality parameters like whiteness, hardness, cooking time, water uptake and swelling index were determined and the results are presented in Table 2.

TABLE 2. WHITENESS, HARDNESS, COOKING TIME, WATER UPTAKE AND SWELLING INDEX OF RAW, CONTROL AND CONDUCTION PARBOILED RICE

Quality		'ADT 36'	'IR 20'	'CO 45'
Whiteness, No.	Raw	52.50	33.00	38.30
	Control	33.70	23.80	26.20
	Parboiled	30.80	21.30	25.20
Hardness, kg	Raw	5.30	4.70	4.60
	Control	8.30	7.50	7.50
	Parboiled	8.20	7.40	7.30
Cooking time, min	Raw	24.00	22.00	25.00
	Control	29.00	28.00	32.00
	Parboiled	27.70	25.30	30.30
Water uptake, g/g	Raw	3.12	2.98	3.15
	Control	2.86	2.73	2.84
	Parboiled	2.88	2.69	2.79
Swelling index	Raw	2.49	2.31	2.69
	Control	2.27	2.18	2.47
	Parboiled	2.31	2.16	2.50

Whiteness : Rice is very sensitive for colour change. Parboiling, depending on the processing condition alters the colour of rice to varying extents. The whiteness value for raw rice 'ADT 36', 'IR 20' and 'CO 45' varieties were 52.5, 33.0 and 38.3 %, respectively. The whitness had reduced by 35.9 % in control for 'ADT 36' and 27.8 % for 'IR 20' and 20.6 % for 'CO 45'. In the optimum parboiled samples of 'ADT 36', 'IR 20' and 'CO 45', the whiteness number ranged between 21.3 and 30.8. The whiteness number of optimum parboiled samples was less than that of control, indicating that there was appreciable change in colour due to method of parboiling. In the present study, the temperature of sand was 140°C and that would have influenced the change of colour in the optimum parboiled rice. Many workers have also observed the influence of temperature of parboiling on the colour of parboiled rice. (Biswas and Juliano 1988).

Hardness : It is clear from Table 2 that the parboiling had increased the hardness of parboiled rice. The increases in hardness values for optimum conduction parboiled samples were to the extent of 50 to 60 % over the raw rice. Similar results have also been reported (Patil et al. 1982). The hardness value of raw rice was between 4.6 and 5.3. In the control samples, the hardness values of 'ADT 36', 'IR 20', 'CO 45' were 8.3, 7.5 and 7.5, respectively. The hardness of optimum parboiled samples was comparable to that of control.

Cooking time : The cooking times of raw rice samples were found to range between 22 and 25 min and those of optimum parboiled samples ranged between 25.33 and 30.33

min. Table 2 revealed that the increase of cooking time of the optimum parboiled rice over the raw rice was to the extent of 18 to 24 %. The increase in the cooking time in the parboiled samples may be due to low hydration capacity at temperatures above their gelatinization temperature. The cooking times of the optimum conduction parboiled samples were less than those of control. It has been indicated that retrogradation in parboiled paddy would be retarded, if its moisture is rapidly reduced, followed by quick dessipation of heat (Ali and Bhattacharya 1976) and this would perhaps, be the main reason for the observed low cooking time observed in the present study.

Water uptake : The water uptake of conduction parboiled rice samples ranged between 2.79 and 2.88 g/g (Table 2). It was clear from the Table 2 that there was no appreciable change in water uptake due to method of parboiling of paddy. However, there was reduction in water uptake in parboiled rice over the raw rice for all the three varieties tested and the values were found to be between 8 and 11 %. This may be due to the fact that the parboiled rice was hard due to gelatinization and resisted the absorption of water into it during cooking. Similar results were also reported by Mahadevappa and Desikachar (1968) and Patil et al (1982).

Swelling index : Table 2 revealed that the swelling index values of parboiled rice samples were lower than that of raw rice. The swelling indices for conduction parboiled samples ranged between 2.16 and 2.50. The changes in the swelling index of the conduction parboiled samples to that of raw rice were in the range of 7.01 to 7.06 %. There was not significant change in the swelling index between the conduction parboiled samples and that of control. Mahadevappa and Desikachar (1968) also reported reduction in swelling index of parboiled samples.

It was concluded that an initial moisture content of 30 % with a contact of 60 sec was the best combination for 'ADT 36', whereas, initial moisture content of 28 % with a contact time of 60 sec was sufficient for 'IR 20' and 'CO 45' samples to get optimum parboiling of these paddy varieties.

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Studies on Development of Instant *Chutneys* from *Pudina* (Mint, *Mentha spicata*) and *Gongura* (*Hibiscus* sp)

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Studies were taken up to standardise the procedure for preparation of instant *chutneys* with *pudina* (mint, *Mentha spicata*) and *gongura (Hibiscus* sp) by using shade dried leaves. Instant *chutneys* were found to reconstitute well in cold water. After seasoning, the *pudina chutney* had all the characteristics of fresh *chutney*. But in the case of *gongura*, the reconstituted *chutney* also had all other characteristics of fresh *chutney* except the mucilaginous property. The products had a shelf life of more than three months at ambient temperature when packed in flexible pouches.

Keywords : *Pudina, Gongura,* Instant *Chutneys.*

Chutneys and pickles are food adjuncts, used as side dishes in Indian meals. They serve as good appetizers and hence are prepared domestically in every household. Of late, they have assumed commercial importance and also find export market. The *chutneys* are made using different vegetables and spices and are available in vinegar, acetic acid, common salt, sugar, mustard oil, with or without preservatives and packed in glass bottles for domestic and export markets.

Pudina (Mentha spicata) and *gongura (Hibiscus* sp*) chutneys* are delicacies of Andhra Pradesh, which are not only used as side dish in meals but are also served along with breakfast items like *dosa, idli, uppuma* etc. However, their preparation is very time consuming. Being intermediate moisture foods and pasty in consistency, their shelf life period is hardly one day, unless preserved under refrigerated conditions. Because of the drudgery involved in preparation of these *chutneys,* they have almost become obsolete in the menu of households. Therefore, an attempt was made to provide these *chutneys* in conveniently packaged dry form so that these would provide a sample of *chutney* after reconstitution with all the required properties. This communication deals with the standardisation of the recipe and process for the preparation of instant *chutneys* from these two leafy vegetables in convenient packs in order that the shelf life period is extended and typical characteristics are retained. Subsequently, they can be rehydrated satisfactorily.

Materials : Fresh *pudina* and *gongura*, green chillies, red chilly, garlic, tamarind, citric acid, salt, cumin, white sesame seeds and vegetable oil were procured from the local market.

Preparation of fresh chutneys : Pudina/gongura leaves were separated from stalks and washed thoroughly in water. Stalks of green chillies, skin of garlic cloves were removed. Tamarind was soaked for 15 min. in water in the ratio 1:2, squeezed and the extract was collected. Green chillies, cloves, cumin and leaves were first fried in the oil and cooked for 10 min. under low flame. Sesame seeds were roasted and powdered along with salt separately in an electrical grinder. The fried and cooked material was added to the sesame powder blended in the grinder, and further ground by adding the tamarind extract to prepare the *chutney* which would have a shelf life of one day (Satyanarayana and Rao 1997 a,b).

Preparation of instant chutneys *:* Fresh *pudina/gongura* leaves were separated from stalks, washed thoroughly in water and dried to approximately 18 % moisture in shade by spreading in perforated trays with free air flow. Sesame seeds were roasted under low flame till light brown in colour. Red chilli, deskinned garlic, and cumin were fried in a small quantity of oil at around 165°C for 2-3 min. All these fried materials along with the shade-dried leaves, salt and citric acid (in case of *pudina*) were ground in an electrical grinder to get 30 mesh free flowing instant *chutney* powders. Flow charts for the preparation of instant *chutney* powders are depicted in Fig. 1 and 2. Unit packs of 100 g were made in

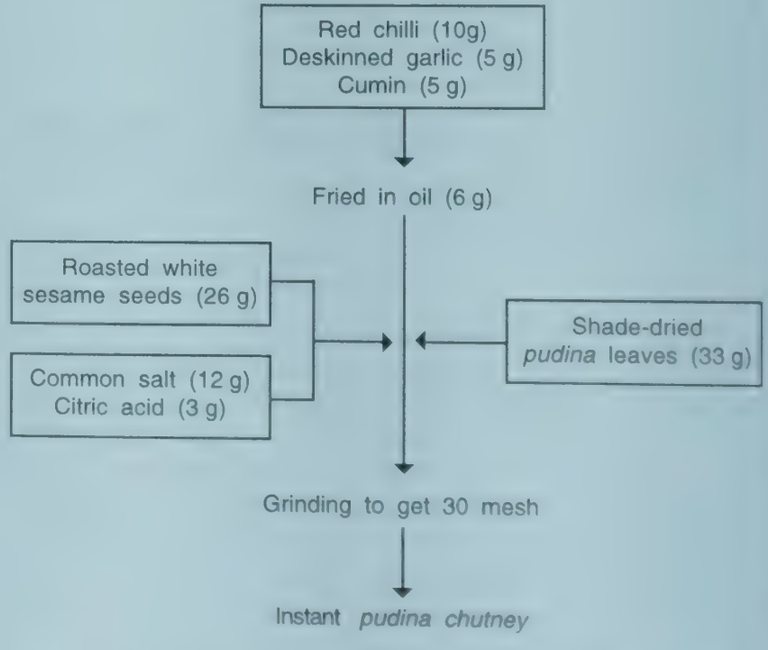
Red chilli (10g)
Deskinned garlic (5 g)
Cumin (5 g)
Fried in oil (6 g)
Roasted white sesame seeds (26 g)
Common salt (12 g)
Citric acid (3 g)
Shade-dried pudina leaves (33 g)
Grinding to get 30 mesh
Instant pudina chutney

Fig. 1. Flow chart for the preparation of instant *pudina chutney*

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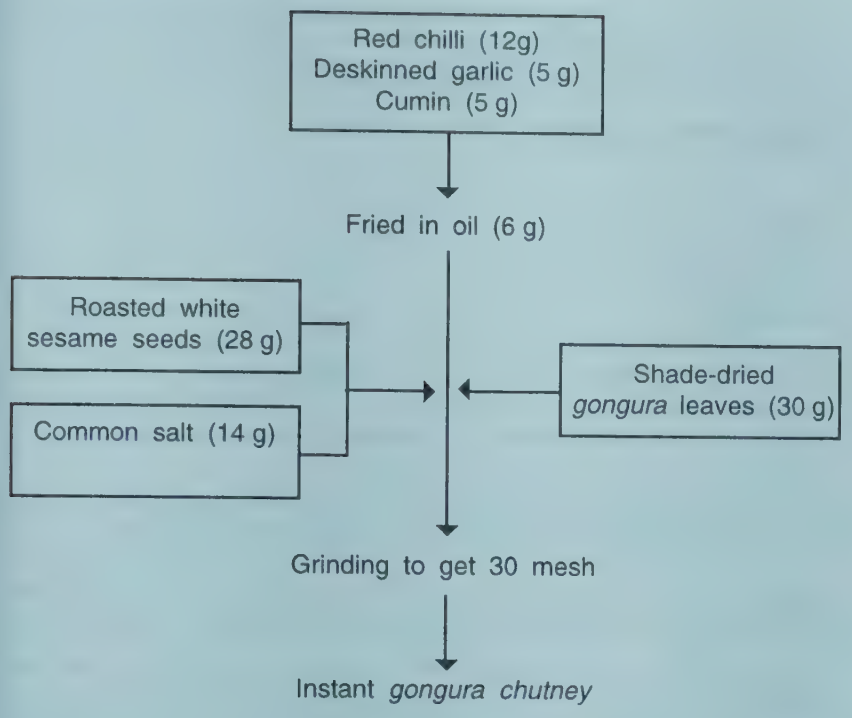
Red chilli (12g)
Deskinned garlic (5 g)
Cumin (5 g)
Fried in oil (6 g)
Roasted white sesame seeds (28 g)
Common salt (14 g)
Shade-dried gongura leaves (30 g)
Grinding to get 30 mesh
Instant gongura chutney

Fig. 2. Flow chart for the preparation of instant *gongura chutney*

HDPE pouches (200 gauge) stored at 28-37°C with RH 32-48 % to study the physico-chemical and organoleptic changes during storage.

Chemical analysis : Moisture, free fatty acids (FFA), peroxide values (PV), total acidity, total ash, acid insoluble ash, total fat, and crude fibre were determined as per standard methods (AOAC 1960). The extracted fat was examined for free fatty acids and peroxide value. pH was determined by reconstituting 10 g of *chutney* powder with 100 ml distilled water. Non-enzymatic browning was determined as per the method of Ranganna (1977). Moisture sorption isotherm characteristics were determined at ambient temperature by exposing weighed quantities of the samples in the petridishes to different relative humidities using appropriate saturated salt solutions (Rockland 1960). The samples were periodically weighed till they attained a constant weight or showed signs of fungal growth. The sensory quality evaluation of the reconstituted *chtuneys* from these instant *chutney* powders were done by comparing with *chutneys* prepared from fresh leaves (control) by a panel of 8 judges using a nine point Hedonic scale with a maximum score of 9 for "like extremely" and minimum of 1 for "dislike extremely" (Amerine et al. 1965). For statistical analysis, the data were subjected to the Analysis of Variance technique as suggested by Panse and Sukhatme (1989).

Reconstitution of instant chutney *powders at room temperature :* The instant *pudina chutney* powder was reconstituted with 2.5 times of its weight of water. It reconstituted to 1.6 times in volume in 10 min. However, the instant *gongura chutney* powder had taken up double the weight of water and reconstituted to twice its volume in 10 min. There was no change in reconstituted volume even after one hour. After 10 min the reconstituted *chutneys* were seasoned with cumin and garlic and left under low flame for 5 minutes to get the thick pasty consistency of fresh *chutneys*.

Pudina and *gongura* were chemically analysed for moisture, total acidity, proteins, crude fat, crude fibre, total ash, acid insoluble ash, carbohydrates, iron and calcium. The results are given in Table 1.

Varying proportions of *pudina/gongura,* sesame seed, salt, green/red (dry) chilli, garlic, cumin, tamarind/citric acid and vegetable oil were investigated to prepare fresh and instant *chutneys* from *pudina* and *gongura.* The recipe was standardized for fresh and instant *chutneys* from *pudina* and *gongura* through a panel of judges. Table 2 gives the recipe which scored maximum in sensory quality testing for instant *chutneys* of *pudina* and *gongura.*

The chemical composition of instant *chutneys* (Table 3) showed that they were rich in fat, protein, and crude fibre. The calorific values of instant *pudina* and *gongura chutneys* were 408 and 429 kcal/100 g, respectively.

TABLE 1. CHEMICAL COMPOSITION OF *PUDINA* AND *GONGURA*

Parameter	*Pudina*	*Gongura*
Moisture*	78.14 ± 0.66	52.58 ± 0.60
Acidity, as citric acid	1.14 ± 0.01	13.08 ± 1.26
Protein (N x 6.25)	26.65 ± 1.52	19.97 ± 1.65
Crude fat	3.48 ± 0.24	3.52 ± 0.24
Total ash	9.83 ± 0.03	5.80 ± 0.43
Acid insoluble ash	0.35 ± 0.09	0.60 ± 0.15
Crude fibre	8.33 ± 0.11	9.47 ± 0.48
Carbohydrates (by difference)	50.56 ± 1.13	48.15 ± 3.11
Iron	0.159 ± 0.019	0.024 ± 0.004
Calcium	1.608 ± 0.054	1.112 ± 0.055

*on fresh weight basis

Values are expressed as percent on dry weight basis

TABLE 2. RECIPE USED FOR PREPARATION OF INSTANT *CHUTNEYS*

Ingredients, %	*Pudina*	*Gongura*
Shade-dried leaves	33	30
Sesame	26	28
Salt	12	14
Red chilli	10	12
Garlic	5	5
Cumin	5	5
Citric acid	3	-
Vegetable oil	6	6

TABLE 3. CHEMICAL COMPOSITION OF INSTANT *CHUTNEYS**

Parameters, %	*Pudina*	*Gongura*
Moisture	4.90	4.05
Total lipids	26.64	27.81
Total protein (N x 6.25)	14.91	15.23
Total ash	19.93	18.37
Acid insoluble ash	0.06	0.09
Crude fibre	6.38	5.10
Carbohydrates (by difference)	27.24	29.44
Energy (kcal/100 g)	408	429

* Average of four replications each

TABLE 4. PHYSICO-CHEMICAL CHANGES IN INSTANT *PUDINA* AND *GONUGURA CHUTNEYS* DURING STORAGE AT AMBIENT TEMPERATURE

Storage period, months	Moisture, %	PV, meq of O_2/kg	FFA, % oleic acid	pH	Acidity, % citric acid	NEB OD at 420 nm
			Pudina			
Initial	4.90	23	1.9	3.85	2.3	0.054
1	4.90	29	1.8	3.88	2.3	0.072
2	4.95	36	2.2	3.86	2.3	0.075
3	5.10	49	2.6	3.80	2.3	0.080
			Gongura			
Initial	4.05	19	1.7	2.90	2.8	0.40
1	4.20	28	2.0	2.92	2.8	0.43
2	4.48	37	2.2	2.90	2.8	0.48
3	4.85	46	2.5	2.94	2.7	0.52

NEB = Non-enzymatic browning

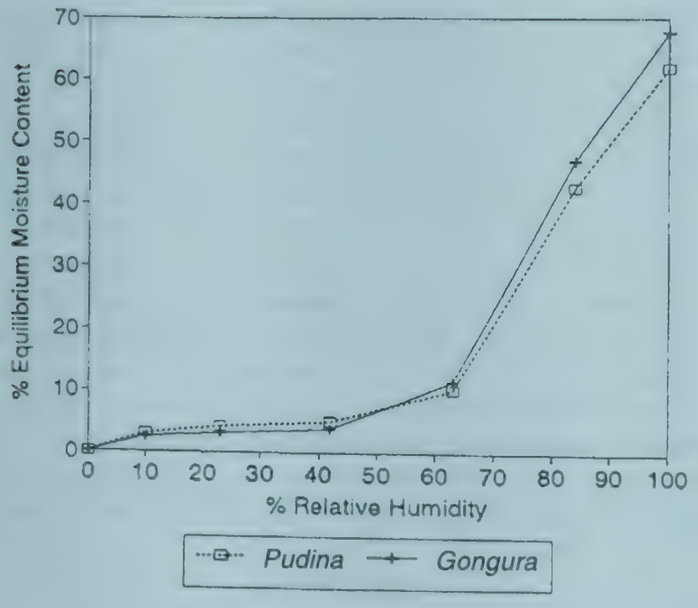

Fig. 3. Sorption isotherms for instant *chutneys*

Moisture-isotherm characteristics of instant *chutneys* of *pudina* and *gongura* are presented in Fig. 3. The instant *pudina chutney* had an initial moisture content of 4.90 % which equilibrates at 42 % relative humidity (RH) at room temperature. Similarly, the instant *chutney* of *gongura* had an initial moisture content of 4.05 %, which equilibrates at 43 % RH. The critical moisture content of *pudina* was 8.5 % and that of *gongura* was 9.2 %, which equlibrated at 63 % and 52% relative humidity respectively. Both the instant *chutneys* had picked up moisture rapidly above 65 % RH, which indicated that the products were highly hygroscopic and required immediate packing.

Table 4 indicates the physico-chemical changes of instant *chutneys of pudina* and *gongura* during the 3 months storage

TABLE 5. ORGANOLEPTIC QUALITY - CHANGES IN OVERALL QUALITY DURING THE STORAGE PERIOD

Storage period, months		*Gongura*	*Pudina*
	0	7.0	8.0
	1	6.5	7.5
	2	6.5	7.0
	3	6.0	7.0
	SEM	0.171	0.092
CD	@ P = 0.05	0.28	0.52
	@ P = 0.01	-	0.74

at ambient temperature. Both the instant *chutneys* behaved similarly during the storage. The moisture content of instant *chutneys* had increased by 0.8 % in *gongura* and remained almost constant in *pudina*. The peroxide values had increased from 23 to 49 and from 19 to 46 in *pudina* and *gongura* instant *chutneys,* respectively. For the same storage period, FFA had increased by 0.7% and 0.8%. The acidity and pH of both instant *chutneys* were almost constant during the storage period. There was a slight increase in non-enzymatic browning in both the instant *chutneys*. The instant *pudina chutney* was rated very good (8) and good (7) and *gongura chutney* was rated good (7) and above average (6) during the storage period of 3 months with respect to colour, texture, flavour and taste (Table 5). The instant *gongura chutney* had scored less due to loss of mucilaginous property which is a characteristic feature of *gongura chutney*.

The study indicated that instant *chutneys* could be prepared from *pudina* and *gongura* with their typical characteristic qualities.

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RESEARCH NOTE

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Studies on the Stability of Some Edible Oils and Their Blends During Storage

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Edible oil blends namely refined rice bran oil : unrefined groundnut oil and refined soybean oil: unrefined groundnut oil were prepared in the proportion of 80:20 v/v and stored in sealed tin containers at room temperature (15-34°C). Both the oil blends remained stable for 15 months without development of perceptible off-flavour or odour. Peroxide, thiobarbituric acid, total carbonyls and anisidine values increased during storage and the changes correlated linearly with the storage period. Free fatty acids increase in raw edible oil was more rapid than in refined oils during storage. In general, the oil blends showed a good stability. However, *pooris* fried in soybean oil blend were less acceptable when sensory analysis was done on a 9 point Hedonic scale.

Keywords : Blended oil, Storage stability, Tin container, Hedonic scale, Fatty acid composition.

Domestic edible oil consumption in India is increasing steadily. India's self sufficiency in edible oils today stands at 85 %. In recent years, availabilities of non-conventional oils such as rice bran oil, soybean oil, palmolein oil and cottonseed oil have increased. Most of these highly unsaturated non-conventional oils are not suitable to be used for frying purposes and also not very acceptable to the consumers, as they are devoid of the regionally preferred flavours of oils traditionally consumed in the country. With a view to promote the consumption of non-conventional oils in India, National Dairy Development Board (NDDB) has introduced under the brand name 'Lokdhara', a blended vegetable oil containing 67 % palmolein and the rest raw groundnut oil. In many countries, edible oil is often marketed as a blend of two or three oils (Murthi et al. 1987). Some work has been carried out on blended oils in India (Premavalli et al. 1998). Murthi et al (1987) reported that the acceptability of oil blends were poor after 120 days of storage in air tight glass bottles incubated at 37°C. The quality characteristics of rice bran oil with groundnut oil and mustard oil blends has been studied by Nasirullah et al (1991). Murthi and Sharma (1981) also reported the accelerated oven stability of soybean-groundnut oil blends in glass bottles at 100°C. In the present investigation, the storage stability of soybean-groundnut oil and rice bran-groundnut oil blends in 15 L tins at room temperature was studied and the results are reported in this communication.

Materials : Refined rice bran oil and refined soybean oil were procured in 15 L square tins within 1 month from the date of manufacture, while unrefined groundnut oil was expeller product. All the reagents and chemicals used for the analytical work were of AR grade.

Preparation of blended oil : Refined rice bran oil (80 %)+ unrefined groundnut oil (20 %) and refined soybean oil (80 %)+ unrefined groundnut oil (20 %) were well mixed manually without bubbling, packed in 15 L tins. All the tins were hermetically sealed and stored at ambient conditions (15-34°C).

Chemical evaluation : Initially and once in three months, the stored samples were drawn from two separate tins each time and analysed for peroxide value (PV), refractive index (RI), thiobarbituric acid value (TBA), free fatty acids (FFA) and iodine value (IV) as per AOCS (1990) methods, anisidine value (AV) as described by List et al (1974), total carbonyls (TC) by Henick et al (1954). Fatty acid composition of oil was determined by standard AOCS (1990) methods using gas liquid chromatography (Model HR 1000, Chemito, Chennai, India) with 10% DEGS column. For sensory evaluation, *pooris* fried in stored oil and their blends were served to a panel of 25 persons for aroma, taste and overall acceptability on a 9-point Hedonic scale, denoting 9 for excellent in all respects and 1 for totally unacceptable. Oil blend samples as such were also served to the panel members for detection of any stored odour.

Off-flavour resulting from oxidation of unsaturated fatty acids is the major cause of spoilage in stored oils. In the present investigation, the oxidation was determined by following changes in peroxide value and the carbonyls, the final products of oxidation. The changes in chemical characteristics of refined rice bran oil, refined soybean oil, unrefined groundnut oil and their blends during storage at room temperature are given in the Tables 1-3. The refined oils had initially lower free fatty acids (0.13 - 0.20 %) than the unrefined groundnut oil (0.31 %). The initial peroxide value of refined oils varied from 2.3 - 3.4 meq O_2/kg oil (Table 1) as compared to 2.6 - 3.8 in refined rice bran-unrefined groundnut oil and refined soybean-unrefined groundnut oil blends, respectively (Tables 2 and 3). After 15 months of storage at room temperature, the peroxide value increased to 7.2 in rice bran-groundnut oil and 13.2 in soybean-groundnut oil blends. Also, it has been found earlier that peroxides increase from 5 - 17 meq O_2/kg in refined soybean oil and from 5 - 7 meq O_2/kg in raw groundnut oil stored upto 12 months (Arya and Premavalli 1990; Yousuf Ali Khan et al. 1979). The free fatty acid contents of all edible oils increased steadily during storage at room temperature (Tables 1-3). This increase was more conspicuous in raw groundnut oil (0.31-0.99%) and was low in refined oils because of low initial values (Table 1). Among the two edible oil blends, soybean

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TABLE 1. CHANGES IN PHYSICAL AND CHEMICAL PARAMETERS IN OILS STORED IN SEALED TINS AT AMBIENT TEMPERATURE

Particulars	Storage period, months	PV	FFA	TBA	IV	TC	AV	RI
RSO	0	3.4	0.13	0.34	125.59	3.55	1.75	1.4725
	6	8.7	0.15	0.55	124.98	8.16	3.94	1.4730
	12	14.9	0.16	0.68	122.81	10.82	5.11	1.4730
	15	19.5	0.18	0.84	122.36	17.91	8.91	1.4735
RBO	0	2.3	0.20	0.25	93.04	10.39	2.57	1.4690
	6	4.6	0.29	0.34	92.16	14.20	18.34	1.4695
	12	6.8	0.32	0.52	91.89	17.19	21.85	1.4705
	15	7.8	0.39	0.68	91.61	23.46	27.16	1.4705
UGO	0	3.1	0.31	0.19	91.41	2.04	1.10	1.4690
	6	4.4	0.68	0.28	91.07	7.28	9.72	1.4690
	12	5.7	0.82	0.40	90.69	10.02	14.67	1.4695
	15	6.9	0.99	0.52	90.28	12.11	18.24	1.4695

Values are mean of three deteminations

RSO - Refined soybean oil, RBO - Refined rice bran oil, UGO - Unrefined groundnut oil

TABLE 2. CHANGES IN PHYSICAL AND CHEMICAL PARAMETERS IN RICE BRAN-GROUNDNUT OIL BLEND STORED IN SEALED TINS AT AMBIENT TEMPERATURE

Particulars	Storage period, months	PV	FFA	TBA	IV	TC	AV	RI
RBO 80 % + UGO 20 %	0	2.6	0.23	0.22	92.4	6.5	1.6	1.4690
RBO 80 % + UGO 20 %	6	4.4	0.46	0.34	91.3	8.1	13.9	1.4690
RBO 80 % + UGO 20 %	9	5.2	0.48	0.43	91.1	9.0	16.7	1.4695
RBO 80 % + UGO 20 %	12	5.8	0.58	0.45	91.0	11.6	17.7	1.4695
RBO 80 % + UGO 20 %	15	7.2	0.63	0.51	90.6	13.1	21.5	1.4695

Values are mean of three deteminations

RBO - Refined rice bran oil, UGO - Unrefined groundnut oil

TABLE 3. CHANGES IN PHYSICAL AND CHEMICAL PARAMETERS IN SOYBEAN-GROUNDNUT OIL BLEND STORED IN SEALED TINS AT AMBIENT TEMPERATURE

Particulars	Storage period, months	PV	FFA	TBA	IV	TC	AV	RI
RSO 80 % + UGO 20 %	0	3.8	0.17	0.28	120.0	2.5	1.5	1.4720
RSO 80 % + UGO 20 %	6	6.7	0.19	0.56	119.6	6.1	4.8	1.4720
RSO 80 % + UGO 20 %	9	6.9	0.22	0.67	118.4	9.8	7.9	1.4725
RSO 80 % + UGO 20 %	12	10.1	0.23	0.69	117.3	11.1	9.3	1.4725
RSO 80 % + UGO 20 %	15	13.2	0.25	0.72	116.9	14.2	11.7	1.4725

Values are mean of three deteminations

RSO - Refined soybean oil, UGO - Unrefined groundnut oil

oil blended with groundnut oil showed lower increase in FFA content (Table 3). A concomitant increase in anisidine value and in the formation of total carbonyls was also observed from 1.6 -21.5 units and 6.5 -13.1 mg/100 g hexanal in rice bran-groundnut oil blend whereas from 1.5 -11.7 units and 2.5 -14.2 mg/ 100 g hexanal in soybean-groundnut oil bend, respectively (Tables 2 and 3). The changes in thiobarbituric acid value also followed the same pattern. The increase in thiobarbituric acid value, anisidine value, peroxide value and total carbonyls were linearly correlated ($r > 0.89$) with the storage period. The correlation coefficient between thiobarbituric acid and storage period ranged between 0.9 and 0.99, whereas it ranged between 0.95 to 0.99, 0.9 to 0.99 and 0.89 to 0.99 in anisidine value, peroxide value and total carbonyls with the storage period respectively. The changes in PV, TBA, AV and TC though significant, were not large enough to cause perceptible change in sensory quality of both oil blends upto 15 months storage at room temperature. Refractive index of rice bran-groundnut oil and soybean-groundnut oil blends ranged from 1.4690 - 1.4695 and 1.4720 - 1.4725, respectively and did not change significantly during the entire period of storage. Iodine value, which normally decreases as a result of oxidation (Semwal et al. 1996), decreased by 2 to 3 units after 15 months of storage in all the edible oils and their blends

TABLE 4. SENSORY ATTRIBUTES[a] OF OIL AND THEIR BLENDS STORED AT AMBIENT TEMPERATURE

Particulars	Storage period, months	Aroma*	Taste*	Overall* acceptability
RBO	0	7.8 ± 0.4	7.9 ± 0.5	7.9 ± 0.4
UGO		8.0 ± 0.5	8.0 ± 0.6	7.9 ± 0.4
RSO		7.6 ± 0.3	7.7 ± 0.4	7.6 ± 0.5
RBO 80% + UGO 20%		7.8 ± 0.4	7.8 ± 0.6	7.8 ± 0.3
RSO 80% + UGO 20%		7.7 ± 0.5	7.6 ± 0.4	7.7 ± 0.6
RBO	6	7.6 ± 0.6	7.7 ± 0.3	7.7 ± 0.4
UGO		7.8 ± 0.5	7.7 ± 0.5	7.8 ± 0.3
RSO		7.5 ± 0.4	7.4 ± 0.2	7.4 ± 0.4
RBO 80 % + UGO 20 %		7.7 ± 0.3	7.6 ± 0.4	7.7 ± 0.5
RSO 80 % + UGO 20 %		7.4 ± 0.2	7.3 ± 0.5	7.3 ± 0.2
RBO	12	7.5 ± 0.3	7.6 ± 0.4	7.5 ± 0.5
UGO		7.6 ± 0.4	7.5 ± 0.3	7.6 ± 0.3
RSO		7.2 ± 0.6	7.3 ± 0.4	7.3 ± 0.2
RBO 80 % + UGO 20 %		7.5 ± 0.3	7.5 ± 0.2	7.5 ± 0.4
RSO 80 % + UGO 20 %		7.3 ± 0.4	7.1 ± 0.2	7.2 ± 0.2
RBO	15	7.3 ± 0.4	7.4 ± 0.3	7.3 ± 0.4
UGO		7.4 ± 0.2	7.4 ± 0.3	7.4 ± 0.2
RSO		7.0 ± 0.4	7.1 ± 0.3	7.1 ± 0.2
RBO 80 % + UGO 20 %		7.3 ± 0.4	7.4 ± 0.4	7.4 ± 0.5
RSO 80 % + UGO 20 %		7.1 ± 0.3	7.0 ± 0.2	7.1 ± 0.3

*Mean of 25 values ± SD

a-Values are not significantly different from their initial values ($p>0.02$)

RBO-Refined rice bran oil,
RSO-Refined soybean oil,
UGO-Unrefined groundnut oil

(Tables 1-3). Increases in PV, TBA and AV were higher in soybean-groundnut oil blend as compared to rice bran-groundnut oil blend. However, both the oil blends remain stable during storage in sealed tin container. Initially, the aroma, taste and overall acceptability of *pooris* fried in oils and their blends were not different, but tended to decrease when fried in stored samples. The consumer acceptance trial indicated preference for rice bran-groundnut oil blend than the soybean-groundnut oil blend (Table 4).

Autooxidation of vegetable oils affects their fatty acid composition, as polyunsaturated fatty acids are oxidised faster than saturated and mono unsaturated fatty acids (Semwal et al 1996). The changes in fatty acid composition of edible oils and their blends during storage are given in Table 5. Individual fatty acid contents (%) in the blends mostly were in agreement with the calculated values. The fatty acid profile of oil blends did not change significantly during storage.

From the foregoing discussion, it is evident that both the oil blends remained in acceptable condition for 15 months without any significant change in flavour when packed in 15 L tins. Increase in peroxide value, thiobarbituric acid value, anisidine value and total carbonyls correlated linearly with the storage period and can be used as objective parameters for quality deterioration on storage.

Authors thank Sri. T.S. Srinivasan for statistical analysis.

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TABLE 5. CHANGES IN FATTY ACID COMPOSITION OF OIL AND BLENDS STORED AT AMBIENT TEMPERATURE

Particulars	Storage period, months	Fatty acids,* % $C_{14:0}$	$C_{16:0}$	$C_{18:0}$	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$	$C_{20:0}$	$C_{22:0}$	$C_{22:1}$	$C_{24:0}$
RSO	0	-	11.6 ± 0.21	3.1 ± 0.04	26.0 ± 0.25	53.3 ± 0.44	5.9 ± 0.06	-	-	-	-
RBO		3.7 ± 0.05	21.4 ± 0.32	1.1 ± 0.03	38.6 ± 0.18	34.8 ± 0.20	-	-	-	-	-
UGO		-	11.3 ± 0.12	2.1 ± 0.05	43.7 ± 0.21	34.8 ± 0.17	-	1.2 ± 0.03	2.5 ± 0.05	1.5 ± 0.03	1.1 ± 0.02
RSO 80 % + UGO 20 %		-	10.8 ± 0.14	2.8 ± 0.07	30.1 ± 0.11	49.6 ± 0.31	5.4 ± 0.03	0.4 ± 0.002	0.2 ± 0.001	-	0.2 ± 0.002
RBO 80 % + UGO 20 %		3.2 ± 0.04	18.9 ± 0.16	1.5 ± 0.06	40.6 ± 0.31	34.3 ± 0.26	-	0.3 ± 0.002	0.2 ± 0.001	-	0.2 ± 0.003
RSO	12	-	12.3 ± 0.11	3.4 ± 0.02	26.8 ± 0.15	52.1 ± 0.27	5.2 ± 0.07	-	-	-	-
RBO		3.9 ± 0.06	21.8 ± 0.28	1.5 ± 0.03	39.1 ± 0.08	33.6 ± 0.14	-	-	-	-	-
UGO		-	11.9 ± 0.09	2.6 ± 0.05	44.2 ± 0.10	33.8 ± 0.19	-	1.3 ± 0.03	2.4 ± 0.02	1.6 ± 0.04	1.2 ± 0.01
RSO 80 % + UGO 20 %		-	11.4 ± 0.13	3.2 ± 0.07	30.9 ± 0.23	48.4 ± 0.11	4.8 ± 0.04	0.5 ± 0.001	0.2 ± 0.003	-	0.1 ± 0.001
RBO 80 % + UGO 20 %		3.7 ± 0.07	19.4 ± 0.20	2.4 ± 0.04	41.0 ± 0.13	33.4 ± 0.28	-	0.2 ± 0.001	0.1 ± 0.002	-	0.1 ± 0.002

*Mean of three values ± SD, Maximum variation among replicates did not exceed 3 % of the mean

RBO - Refined rice bran oil,
RSO - Refined soybean oil,
UGO - Unrefined groundnut oil

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RESEARCH NOTE

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Studies on Development of a Process for Preparation of Fermented Carbonated Whey Beverage

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A process developed for the preparation of fermented carbonated whey beverage was found highly acceptable with respect to sensory and physico-chemical qualities. The heat and chemical pre-treatments given to whey for clarification also improved physical qualities. The developed fermentation process imparted acceptable lactic acid flavour by hindering unacceptable odour of natural whey. The carbonation of beverage further helped in improving the acceptability. A sugar level of 12.0 %, pineapple flavour of 0.1 % and carbonation of 72.48 kg cm^{-1} were found most acceptable and the product was liked extremely well by the judges.

Keywords : Beverage, Pre-treatments, Fermentation, Carbonation, Whey, Sensory attributes.

Whey is one of the most important byproducts from the Indian dairy industry obtained mainly during the manufacture of *channa* and *paneer* in India. Whey contains almost all the nutrients of milk except casein and fat, thus making it highly nutritious. Unfortunately, whey is presently being drained-off due to absence of economically viable methods for its utilization, which not only causes losses of precious nutrients but also creates environmental problems due to its high biological oxygen demand (BOD). Total amount of whey produced in India is more than 16000 metric tonnes annually alone from cheese industry, while production from other sources such as *paneer, chhana*, casein etc. is not known. Worldwide production of whey is reported to be 1.5 million metric tonnes per annum (Shilpa and Gandhi 1993). In view of rapid expansion programme in dairy industry, it is expected that more quantities of whey will be available in the near future. Yet, there are no published reports, relevant to the utilization of whey on commercial scale in human foods in India. Whey could be used in the formulation of nutritious, palatable and therapeutic lactic fermented soft drinks which impart fresh flavour. Whey is also known to suppress the growth of pathogenic and spoilage organisms (Gandhi 1984). Conversion of whey into a beverage on a commercial scale has an economic advantage, as the whole quantity is being used and there are no problems of left over residues. Beverages in general, provide energy, water to digest food, regulate body temperature, prevent dehydration, quench thirst and remove psychological tensions. Taking into consideration the production and importance of whey, the present investigation was undertaken to utilize the whey in the preparation of fermented carbonated whey beverage and to study its physico-chemical and sensory qualities.

Fresh buffalo milk was standardized to 6.0 % fat, heated to 82°C and cooled to 70°C. Simultineously, 2 % citric acid solution was prepared and brought to 70°C and used to coagulate milk. Whey was drained through muslin cloth and passed through a cream separator to make it fat-free. The whey was clarified by precipitating the whey proteins by heat and chemical treatments separately.

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Heat clarification : This was attempted by heating whey at 98°C for 10 min at pre-adjusted pH of 4.5 by using citric acid. It was then cooled to room temperature and kept for 5 to 6 h to allow the precipitated proteins to settle down. The clarified whey was obtained by decanting through double folded muslin cloth.

Chemical clarification : This was done by heating the whey at pH 4.5 at the temperature of 98°C, followed by addition of 0.2 % $CaCl_2$ and heating continued for 10 min. Then, it was cooled to room temperature and kept for 5 to 6 h to allow the precipitated proteins to settle down. Then, the clarified whey was obtained by decanting through double folded muslin cloth.

Both types of clarified whey were tested for sensory attributes on a 9-point Hedonic scale, by a panel of 10 judges. Based on the overall acceptability among the two clarification methods, one was selected for further study.

Fermentation of whey : The clarified whey was sterilized at 6.8 kg in^{-2} for 20 min in an autoclave and cooled to 40°C and inoculated with active starter culture of *Streptococcus thermophillus* and *Lactobacillus bulgaricus* (1:1) at the rate of 4.0 %. After incubating it at 39 ± 1°C for 12 h, the fermented whey was obtained by decanting through double folded muslin cloth.

Preparation of whey beverage base : The clarified fermented whey was adjusted to pH 3.0 with citric acid, to which sugar was added at the rate of 10.0, 12.0 and 14.0 % levels in the form of sugar syrup prepared in whey itself. Then, it was heated to 82°C - 85°C for 5 min, cooled to room temperature and finally to refrigeration temperature. This prepared whey beverage base was subjected to sensory analysis on a 9-point Hedonic scale by a panel of 10 judges. The product adjudged as the best was used for further studies.

Preparation of whey beverage : To the product adjudged as the best sugar in adequate level was added with orange colour and three flavours viz., orange, pineapple and Kalakhatta: orange (1:1) at 1.0 % level. The product was then subjected to sensory evaluation to decide the acceptable

flavour. The product adjudged as the best for flavour was selected for carbonation at three different pressures viz., 63.42, 72.48 and 81.54 kg cm^{-2} at 10 to 12°C temperature.

Sensory evaluation of carbonated whey beverage : The products were subjected to sensory evaluation for appearance, colour, taste, aroma, consistency, mouthfeel and overall acceptability on a 9-point Hedonic scale developed by Quarter Master Food and Container Institute, USA (Gupta 1976).

Physico-chemical analysis : The pH and colour of the carbonated whey beverages were measured by using digital pH meter and Lovibond Tintometer, respectively. The OD and % transmission were measured by Haake's Roto Viscometer, RV-20 model (Germany) calibrated at 32°C temperature by using NV system at 1(S^{-1}) shear rate. The sedimentation of beverage was determined by centrifugation. Ten ml of sample was transferred to centrifuge tube and centrifuged at 10000 rpm for 20 min. The supernatant was decanted and measured. The difference between initial volume and final volume gave sediment present in 10 ml and then expressed as % sedimentation.

Moisture, total solids, fat, proteins, lactose, sugar, ash, sucrose and acidity of beverage were measured by using standard methods of ISI (1981).

The data were statistically analyzed by simple RBD as per the method of Panse and Sukhatme (1967).

The effect of clarification method on sensory qualities of *paneer* whey (Table 1) was significant on all attributes. The highest sensory score of 8.0 each was recorded with respect to appearance and colour of whey treated with 0.2 % $CaCl_2$ which may be due to sparkling clear nature of the product as was liked very much by the judges. But the scores for taste, aroma and mouth feel of $CaCl_2$ treated whey were observed minimum due to bitter taste imparted by the $CaCl_2$. The overall acceptability of heat-treated whey was superior as compared to that of control and $CaCl_2$ treated whey.

Heat-clarified fermented whey, therefore, was selected for standardization of whey beverage base for adjusting sugar levels and flavour combinations. It was observed (Table 2) that sugar had no significant effect on appearance and colour of whey beverage base. The highest score of 8.0 each was

TABLE 1. EFFECT OF CLARIFICATION METHOD ON SENSORY QUALITIES OF *PANEER* WHEY

Clarification treatment (Method)	Sensory attributes *						
	Appearance	Colour	Taste	Aroma	Consistency	Mouthfeel	Overall acceptability
Control, untreated	6.00	6.00	6.00	6.00	5.00	6.00	5.80
Heat treatment, 98°C for 10 min	7.00	7.00	7.00	7.00	6.00	7.00	6.80
Chemical treatment, 0.2 % $CaCl_2$ at 90°C for 10 min	8.00	8.00	1.00	1.00	7.00	1.00	4.30
SE ±	0.23	0.27	0.32	0.30	0.35	0.27	1.35
CD at 5 %	0.60	0.69	0.83	0.76	0.89	0.71	3.45

Each value is mean score of ten judges in three trials *Max. score 9.0

TABLE 2. EFFECT OF SUGAR LEVELS, FLAVOUR COMBINATION AND LEVELS OF CABRONATION ON SENSORY QUALITIES OF WHEY BEVERAGE BASE

Treatments	Sensory attributes *						
	Appearance	Colour	Taste	Aroma	Consistency	Mouthfeel	Overall acceptability
Sugar levels, %							
10	7.00	7.00	7.00	7.00	6.00	7.00	6.80
12	7.00	7.00	8.00	8.00	7.00	8.00	7.00
14	7.00	7.00	6.00	6.00	6.00	6.00	6.30
SE ±	-	-	0.45	0.39	0.32	0.36	0.22
CD at 5 %	NS	NS	1.16	1.00	1.81	0.94	0.57
Type of flavour							
Orange	7.00	7.00	8.00	8.00	8.00	8.00	7.60
Pineapple	7.00	7.00	8.60	8.60	8.60	8.60	8.00
Kalakhatta:Orange (1:1)	7.00	7.00	6.60	6.60	6.60	6.60	6.10
SE ±	-	-	0.29	0.29	0.25	0.24	0.23
CD at 5 %	NS	NS	0.74	0.74	0.65	0.74	0.60
Carbonation levels							
Control, Uncarbonated	7.00	7.00	5.00	5.00	6.00	5.00	5.80
63.42 kg cm^{-2}	7.00	7.00	8.00	8.00	8.00	8.00	7.60
72.48 kg cm^{-2}	7.00	7.00	9.00	9.00	8.00	9.00	8.10
81.54 kg cm^{-2}	7.00	7.00	6.00	6.00	7.00	6.00	6.50
SE ±	-	-	0.36	0.34	0.33	0.23	0.44
CD at 5%	NS	NS	0.89	0.83	0.82	0.57	1.07

Each value is a mean score of ten judges in three trials *Max. score 9.0

TABLE 3. SENSORY QUALITIES OF FERMENTED WHEY BEVERAGE

Treatments	Sensory attributes *						
	Appearance	Colour	Taste	Aroma	Consistency	Mouthfeel	Overall acceptability
Market sample **	7.00	7.00	8.00	8.00	7.50	8.00	7.60
Fermented carbonated whey beverage	7.00	7.00	9.00	9.00	8.00	9.00	8.50

Each value is the mean score of ten judges in three trials **Brand name of market sample is withheld *Max. score 9.0

TABLE 4. PHYSICO-CHEMICAL QUALITIES OF FERMENTED CARBONATED WHEY BEVERAGE

	Market sample*	Fermented carbonated whey beverage
Physical attributes		
Colour	4.3 R + 30.0 Y	4.2 R + 32.0 Y
OD at 575 nm	0.75	0.82
% transmission at 575 nm	18.7	13.1
Viscosity at 1 (S^{-1}) shear rate, cp	5.91	7.91
Sedimentation, %	0.25	1.50
Chemical attributes		
Moisture, %	86.9	83.9
Fat, %	0.0	0.2
Proteins, %	0.0	0.22
Lactose, %	0.0	2.98
Sucrose, %	13.0	12.0
Ash, %	0.05	0.62
Total solids, %	13.0	16.0
Acidity, %	0.25	0.20
pH	2.98	3.20

Each value is the mean of three determinations. *Brand name of the market sample is withheld. R = Red: Y = Yellow

recorded for 12.0 % sugar level with respect to taste, aroma and mouthfeel of the beverage base. The overall acceptability of 12.0 % sugar level was found better. The results of the present study are with the close agreement with those of Srivastava et al (1985) and Jayaprakash et al (1986).

As regards to the flavours, pineapple was liked extremely over orange and orange: Kalakhatta (1:1) combinations. Table 2 further revealed that effect of levels of carbonation was significant for all sensory parameters of whey beverage base, except appearance and colour. The carbonation of whey beverage at 72.48 kg cm^{-2} pressure level was liked extremely by the judges than that of control and other levels of carbonation. This may be due to the characteristics CO_2 taste at this pressure. Jayaprakash et al (1986) reported maximum mean score of 9.0 (out of 10.0) and found most acceptable whey beverage carbonated at this pressure, which was in agreement to the results of the present study.

Table 3 reveals that the sensory qualities of finally prepared whey beverage under study dominated the market sample. The highest score of 9.0 each was recorded with respect to taste, aroma and mouthfeel and the products were liked extremely in comparison with market sample. This could have been due to additional fresh lactic flavour development by fermentation process. The score for consistency of market sample and developed beverage were observed to be 7.5 and 8.0, respectively and the slightly higher score to beverage may be due to its turbid nature, which was liked very much by the judges. The overall acceptability of beverage under study was also better than market sample. Jayaprakash et al (1986) and Grinaene and Pratshyavichyus (1976) reported similar results.

The data on physico-chemical qualities (Table 4) showed the improvement in this beverage over market sample. The beverage was found to be more viscous than market sample due to the presence of whey proteins. The whey proteins are known to display minimum solubility in acidic pH (pH 3.0 of whey beverage). These results are in close confirmation with those reported by Holsinger et al (1974) and Albrecht (1986). The data further reveal that the whey beverage was superior in all aspects of chemical quality as compared to that of market sample.

The results of this study have indicated that the process developed for preparation of fermented carbonated whey beverage was highly acceptable in terms of sensory and physico-chemical qualities. Such prepared product was liked better by the judges as compared to the market sample.

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Quality of Smoked Spent Hen Meat Treated with Ginger Extract

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Effect of incorporation of ginger extract (GE) in curing solution on the microbial and organoleptic quality of smoked spent hen meat was studied. Chicken halves were cured for 72 hr at 4 ± 1°C in a standard curing solution (control) containing salt, nitrite, sugar, phosphate and ascorbate or in standard curing solution incorporated with 2.5 % v/v GE treatment. After curing, chicken halves were smoked for 5 h in a smoke oven and stored at room temperature (25 ± 1°C). Incorporation of GE in the standard curing solution significantly ($P<0.05$) reduced the shear force values and improved the sensory attributes of smoked product. Samples cured in GE have comparatively lower TBA numbers and microbial counts than control. Control samples were spoiled, while treated samples remained acceptable on the 5th day of storage at room temperature.

Keywords : Spent hen meat, Ginger, Curing, Smoking, Antioxidant, Antimicrobial, Sensory qualities.

The number of layer and broiler population in India has increased from 18 and 4 million in 1971 to 103 and 530 million, respectively in 1996 and the egg production has increased from 6 billion to 30 billion during the same period (Chatterjee 1999). This has resulted in increased availability of broiler and layer parent stock. The disposal of these spent hens is, therefore, becoming more and more difficult due to inherent quality differences between broiler and spent hen meat.

Development of processed convenience food products or improving the qualities of spent hen meat are considered as potential solutions to the problems of utilizing spent hen meat. To achieve efficient utilization of spent hen components, many workers have attempted to develop convenience products like sausages (Kondaiah et al. 1988), patties (Anjaneyulu and Sharma 1991), kababs (Rao 1996) and smoked chicken (Shrama et al. 1973).

Recently ginger extract has been investigated as an effective tenderizing agent for beef (Lee et al. 1986) and buffalo meat (Syed Ziauddin et al. 1995). Besides tenderizing properties, antioxidant and antimicrobial characteristics of GE have been reported (Salzer 1982, Lee et al. 1986, Kim and Lee 1995). Extension of shelf life by use of GE has also been reported by Syed Ziauddin (1996) and Zhang et al (1996). The present study was undertaken to utilize GE for production of convenience value added and ready-to-eat cured and smoked product from spent hen meat.

Broiler spent hens of 4.5-5.0 kg live weight (about 52 weeks age) were slaughtered and the carcasses were chilled at 4 ± 1°C for 24 h, split bilaterally into two halves. Ginger extract was prepared by blending fresh ginger rhizome with equal quantity of chilled distilled water.

Twelve halves were used in each trial i.e., 6 halves for each treatment. Control carcasses were immersed in standard curing solution consisting of 5 % sodium chloride, 1.5 % cane sugar, 150 ppm sodium nitrite, 450 ppm sodium ascorbate and 0.5 % sodium tripolyphosphate. For treatment, carcasses were immersed in the above standard curing solution incorporated with 2.5 % v/v ginger extract. All carcass halves were immersed for 72 h at 4 ± 1°C. After complete curing, halves were washed in tap water and were smoked in smoke oven (Enviro-Pak, Micro-Pack series MP 500). The birds were smoked in a smoking chamber in 6 stages. The smoking was done at 50°C for 1 h (stage 1), 75°C for 1 h (stage 2), 85°C for 30 min (stage 3) and 95°C for 30 min (stage 4). The humidity in all stages was kept at 45 %. In stage 5, oven temperature was kept at 98°C till core temperature reached 85°C. After attaining 85°C core temperature, birds were cooked for 30 min (stage 6). For storage studies, 4 halves (two each of control and treatment) were analyzed on 0 day and the remaining 8 halves were packed under partial vacuuming in LDPE-foil laminate pouches and stored at 25 ± 1°C. Packed samples were analyzed on 5th and 10th day of storage for various physico-chemical, microbiological and sensory parameters. pH was determined by standard procedure using digital pH meter (Century Inst. Ltd). Analysis of moisture was carried out as per AOAC (1995) method. Extract release volume (ERV) was determined as per the procedure described by Strange et al (1977). Cores of 1 cm^3 were drilled parallel to the muscle fibre for Warner Bratzler shear measurement. Sample extracted with 20 % trichloroacetic acid (TCA) was used for the determination of thiobarbituric acid (TBA) value (Witte et al. 1970) and tyrosine value (Strange et al. 1977). Total plate counts, yeast and mould counts and proteolytic counts were determined following the methods described by ICMSF (1978). The sensory evaluation for appearance, flavour, juiciness, tenderness, saltiness and overall acceptability was performed by trained panel members on an 8-point descriptive scale (where 8 = extremely desirable, 1 = extremely undesirable (Keeton 1983).

The data generated from three trials were analyzed by following standard procedures (Snedecor and Cochran 1968) for analysis of variance and Duncan's multiple range test.

Mean shear force (kg/cm^2) values of freshly cooked (0 day) control and treated samples were 1.68 ± 0.12 and 1.28 ± 0.06, respectively. The values were significantly ($P<0.05$) lower for treated samples as compared to control. Decrease in shear force values by treatment with GE were also reported

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by Thompson (1973), Lee et al (1986) and Syed Ziauddin et al (1995). The yield of the smoked product was 78.7 ± 0.34 and 78.8 ± 1.13 % for control and treated samples respectively which did not differ significantly.

There was no significant difference between pH of control and treated samples of both leg and breast portions (Table 1). Moisture content of leg portion did not differ significantly. However, in breast portion, moisture content of treated samples was significantly higher than control, possibly due to more absorption of curing solution by breast muscle. The changes in moisture content during storage period were non-significant. Mean values of ERV did not differ significantly between control and treated samples. However, ERV values decreased significantly ($P<0.05$) during storage. Jay and Shelf (1976) also recorded the reduction in ERV during storage due to increase in the microbial load which in turn caused pretolysis and increase in the hydration capacity of meat proteins. TBA values did not differ significantly between control and treated samples. In general, relatively low TBA values for the smoked product may be due to the combined effect of nitrite and wood smoke (Pearson and Gillet 1996). Slightly lower TBA values in treated samples compared to control is an indicative of antioxidant effect of ginger extract (Lee et al. 1986; Negbenebor 1995). There was no significant difference between tyrosine value of control and treated samples. However, tyrosine value increased significantly ($P<0.05$) during storage. The increase in proteolysis resulting in higher tyrosine value in the meat stored at ambient temperature were also reported by Syed Ziauddin et al (1993).

Results of microbiological quality parameters (Table 2) revealed no significant difference in total plate counts, yeast and mould counts, and proteolytic counts between control and treated samples. The total counts were comparatively lower in GE treated samples than control as also reported by other workers (Salzer 1982, Negbenebor et al. 1995, Kim and Lee 1995). Inhibition of various spoilage organisms by use of ginger extract in meat products is also reported by Meena and Sethi (1994). Preservative quality of ginger was attributed to the presence of some active antimicrobial principles contained in ginger (Sreenivasmurthy and Krishnamurthy 1959).

Sensory evaluation results of freshly smoked product (Table 3) revealed improvement in flavour, juiciness, tenderness and overall acceptability of samples cured in solution containing GE. Due to visible mold growth in the control samples on the 5th day of storage in all the trials, sensory evaluation was not carried out. Treated samples were also found to be spoiled on the 10th day of storage. Therefore, no parameters were evaluated on the 10th day. The increase in shelf life of ginger treated samples might be due to antioxidant and antimicrobial properties of GE as evident from lower TBA values and total plate counts. The increase in shelf life of meat and meat products treated with ginger extract was also reported (Lee et al. 1986; Kim and Lee 1995, Negbenebor et al. 1995; Syed Ziauddin et al. 1996).

TABLE 1. EFFECT OF GINGER EXTRACT TREATMENT ON PHYSICO-CHEMICAL CHARACTERISTICS OF SMOKED CHICKEN STORED AT ROOM TEMPERATURE (25 ± 1°C)

Product	Storage period, days 0	5	Overall mean
	pH, (leg)		
Control	6.6 ± 0.22	6.2 ± 0.16	6.4 ± 0.14
Treated	6.4 ± 0.15	6.2 ± 0.09	6.3 ± 0.09
Days mean	6.5 ± 0.12	6.2 ± 0.08	
	pH, (Breast)		
Control	6.3 ± 0.15	6.0 ± 0.09	6.2 ± 0.10
Treated	6.2 ± 0.13	6.1 ± 0.13	6.1 ± 0.08
Days mean	6.3 ± 0.09	6.1 ± 0.07	
	Moisture (Leg), %		
Control	61.8 ± 0.47	61.2 ± 0.25	61.5 ± 0.27
Treated	62.6 ± 1.19	61.9 ± 1.25	61.2 ± 0.78
Days mean	62.2 ± 0.60	61.5 ± 0.59	
	Moisture (Breast), %		
Control	64.7 ± 2.33	64.3 ± 2.17	64.5 ± 1.42[1]
Treated	68.7 ± 1.13	67.9 ± 1.15	68.3 ± 0.74[2]
Days mean	66.7 ± 1.47	66.1 ± 1.36	
	Extract release volume, ml		
Control	23.3 ± 2.40	17.8 ± 2.16	20.6 ± 1.89
Treated	26.7 ± 2.90	19.3 ± 1.45	23.0 ± 2.19
Days mean	25.0 ± 1.84[a]	18.6 ± 1.21[b]	
	Thiobarbituric acid number, mg melonaldehyde/kg		
Control	0.3 ± 0.31	0.5 ± 0.10	0.4 ± 0.06
Treated	0.3 ± 0.02	0.4 ± 0.04	0.4 ± 0.02
Days mean	0.3 ± 0.01[a]	0.4 ± 0.05[b]	
	Tyrosine value, mg tyrosine/100 g		
Control	13.8 ± 1.86	20.5 ± 3.25	17.1 ± 2.26
Treated	15.0 ± 2.39	21.0 ± 1.75	18.0 ± 1.89
Days mean	14.4 ± 1.38[a]	20.8 ± 1.65[b]	

Number of observations = 3

Mean values bearing different superscripts row-wise (alphabets) or column-wise (numericals) differ significantly ($P<0.05$)

TABLE 2. EFFECT OF GINGER EXTRACT TREATMENT ON MICROBIOLOGICAL QUALITIES OF SMOKED CHICKEN STORED AT ROOM TEMPERATURE (25 ± 1°C)

Product	Storage period, days 0	5	Overall mean
	Total plate count, log cfu/g		
Control	2.8 ± 0.48	7.3 ± 0.67	5.1 ± 1.06
Treated	2.8 ± 0.44	6.1 ± 0.07	4.5 ± 0.75
Days mean	2.8 ± 0.29[a]	6.7 ± 0.40[b]	
	Yeast and mold count, log cfu/g		
Control	2.7 ± 0.38	5.3 ± 0.12	4.0 ± 0.60
Treated	2.7 ± 0.30	5.2 ± 0.32	3.9 ± 0.60
Days mean	2.7 ± 0.21[a]	5.2 ± 0.08[b]	
	Proteolytic count, log cfu/g		
Control	1.3 ± 0.25	5.3 ± 0.39	3.3 ± 0.92
Treated	1.4 ± 0.19	5.8 ± 0.17	3.6 ± 0.99
Days mean	1.3 ± 0.15[a]	5.5 ± 0.22[b]	

Number of observations = 3

Mean values bearing different superscripts row-wise (alphabets) or column-wise (numericals) differ significantly ($P<0.05$)

TABLE 3. EFFECT OF GINGER EXTRACT TREATMENT ON SENSORY ATTRIBUTES* OF SMOKED CHICKEN STORED AT ROOM TEMPERATURE (25 ± 1°C)

Product	Storage period, days 0	5	Overall mean
Appearance			
Control	7.1 ± 0.11	Spoiled	-
Treated	7.1 ± 0.06	7.0 ± 0.09	7.0 ± 0.05
Days mean	7.1 ± 0.06	-	
Flavour			
Control	6.6 ± 0.10	Spoiled	-
Treated	6.9 ± 0.11	6.7 ± 0.12	6.8 ± 0.08
Days mean	6.7 ± 0.08	-	
Juiciness			
Control	6.5 ± 0.10	Spoiled	-
Treated	6.9 ± 0.09	6.7 ± 0.12	6.8 ± 0.08
Days mean	6.7 ± 0.07	-	
Tenderness			
Control	6.6 ± 0.12	Spoiled	-
Treated	7.1 ± 0.09	6.9 ± 0.17	7.0 ± 0.10
Days mean	6.9 ± 0.09	-	
Saltiness			
Control	6.9 ± 0.12	Spoiled	-
Treated	7.2 ± 0.11	6.9 ± 0.16	7.0 ± 0.10
Days mean	7.0 ± 0.08	-	
Overall acceptability			
Control	6.5 ± 0.10	Spoiled	-
Treated	7.0 ± 0.04	6.4 ± 0.15	6.7 ± 0.92
Days mean	6.8 ± 0.07	-	

Number of observations = 21

*8-point descriptive scale (1: extremely undesirable; 8: extremely desirable)

These results clearly demonstrated the tenderizing, antioxidant and antimicrobial properties of GE. Therefore, this natural spice can be effectively utilized to improve the qualities of tough meat to produce convenience, attractive and highly palatable smoked product with improved shelf life.

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RESEARCH NOTE

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Preparation of Onion Powder by Means of Osmotic Dehydration and its Packaging and Storage

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Onion powder prepared from 5 mm thick osmotically dehydrated onion slices after drying in a cabinet dryer at 60°C for 10 h, grinding in a laboratory powder mill and sieving with 30 mesh sieve, can be stored up to 6 months in 400 gauge LDPE or 200 gauge HDPE pouches at 7°C compared to 4 months at ambient condition with better pungency. Retention of colour and pungency as pyruvic acid was found to be more in the samples packed in 200 gauge HDPE pouches followed by 400 gauge and 200 gauge low density polyethylene (LDPE) pouches, stored at 7°C. For storage of the product having 3.85 % moisture, the optimum RH was found to be 47.5 % and the critical and danger points as 9.14 % and 6.75 % moisture respectively. The product was stable at low temperature as compared to high temperature in respect of colour and flavour.

Keywords : Onion powder, Osmotic dehydration, Common salt, Pyruvic acid, Packaging material, Drying ratio, Storage, Equilibrium Relative Humidity (ERH).

Dehydrated products are wholesome, nutrious and patable but they have not found popular acceptance because the product do not retain the flavour, colour and texture of the original fruit and vegetables after rehydration. Recently, osmotic dehydration which is the process of water removal by immersion of a water containing cellular solids in a concentrated aqueous solution of fruits and vegetables are gaining attention due to its important role in food processing industry because the product by osmotic process is more stable during storage due to low water activity by solute gain and water loss. As at low water activity, all the chemical reactions to deteriorate the food, the growth and toxins production by microorganisms are low. Beside of that it improves the quality of the product in terms of colour, flavour and texture and it is less energy intensive process than air or vacuum drying process (Shafiur Rahman 1992).

Dehydrated and processed vegetables constitute around 40-42 % of total export of processed products both by volume and by value, prominent among them are dehydrated onion flakes and powder (Chadha 1995). Dehydrated onion has become a standard ingredient in nearly every processed food product in which raw onion can be used. Powdered onion can be used in processed foods, where actual pieces are not desired.

Dehydrated onions are the single largest import items in Germany, United States, United Kingdom and Netherland both in quantity and value items, as it used by every canteens, cafeterias, restaurants and other institutional food establishment. Osmotic dehydration increase both equilibrium and drying rate with the increase of osmotic syrup concentrations (Sharma et al, 1991, Islam and Flink 1982).

A large quantity of onion is used as fresh, however, some quantity of it is also processed into its powder by dehydration and are meant mainly for export and for armed forces personnel (Pawar et al, 1988). The onion powder prepared from osmotically dehydrated onion slices have salty taste can be used in processed food where whole pieces are not desired. Like any other powders, onion powder prepared from osmotic dehydrated onion slices also undergo lots of physical and chemical changes if it is not properly packed and stored. Free flowing difficulty and caking are common problems in onion powders due to moisture exchange between food product and its surrounding atmosphere. These changes can be controlled after providing adequate packaging. Hence the present investigation was undertaken to prepare a fine quality powder and find out its packaging and storage requirement.

Medium to large size onion bulbs were procured from the local market of Delhi. After peeling, onion bulbs were cut into slices of 5 mm thickness with a vegetable slicer. The slices were placed in different containers holding 5, 10, 15 and 20 % common salt at ambient temperature and slices were stirred at regular intervals. After 6 h, the slices were removed quickly and drained. The slices were loaded on an aluminium tray at 2 kg/sq.m. and then dried in an electric cross flow of hot air at a flow rate of 1.20-1.80 m/sec at a temperature of 60°C in a cabinet drier (Kilburn make, Model-0248) for 10 h to a final moisture content of 4.12 % in the dehydrated slices. Slices were powdered by grinding in a Willy laboratory powder mill (3375-E 10 Model-4), followed by sieving with 30 mesh sieve. Onion powder was packed in 200 and 400 gauge low density polyethylene (LDPE), and 200 gauge high density polyethylene (HDPE) pouches of 8 x 6 cm, as suggested by Ranganna (1986) and stored at room temperature (18-35°C, 50-60 % RH), and low temperature (7°C, 85 % RH). The product was analysed at 0 and 6 months storage period.

Moisture content was determined by drying the samples to a constant weight in a hot air oven (Ranganna 1986). Acidity was determined as pyruvic acid by titrating the sample (known volume) against standard NaOH solution using phenolphthalein as an indicator by the method of Schwimmer and Guadgi (1962). Ascorbic acid was estimated by titrating a known weight of the sample with 2, 6-dichlorophenol indophenol dye (AOAC 1975). Reducing and total sugars were determined by titrating the samples against Fehling's solution using methylene blue as an indicator (Lane and Eynon (1923). Browning in onion powder was measured in terms of optical density at 420 nm of an aliquot of 60 % alcoholic extract

(Ranganna 1986). The rehydration of dehydrated onion slices was done according to FPO specifications. Ten grams of dehydrated onion slices were reconstituted by steeping in ordinary water at room temperature for 4 h (FPO 1955). The onion powder prepared from 15 % salt solution, which was found to be better on the basis of sensory evaluation, was used for equilibrium relative humidity (ERH) studies to find out the suitable packaging requirement for stable shelf life of onion powder. The critical and danger points were evaluated according to the weight equilibrium method of Wink (1946). Sensory evaluation of the onion powder was investigated to ascertain if any objectionable flavour changes occurred in the product during the osmotic dehydration process. Sensory evaluation was done by Hedonic procedure as described by Amerine et al (1965).

The corresponding losses of water and other chemical constituents during the osmotic process in the dehydrated onion slices which were used for the preparation of onion powder is given in (Table 1). It can be seen from the Table that higher loss of water had occurred in the sample treated with 5 % salt as compared to 10 %, 20 % and 15 % salt. This may be due to maximum mass transfer taking place in 5 % common salt as compared to minimum, treated with 20 % salt. The rate of water removal and salt uptake were maximum at the beginning of the osmotic-dehydration process which decreased gradually with the increase in salt concentration (Lenart and Flink 1984). Dehydration or drying ratio (DR) and rehydration ratio (RR) was found to be best in the samples treated with 15 % salt in both cases - cold water (ambient temperature) as well as in hot (70°C) water. Rehydration ratio of osmotically dehydrated onion slices was slightly less than untreated in both rate and extent. It may be due to osmotically treated product does not take up as much water, which means a crisper texture, this would be an advantage for eating out of hand. Besides, osmotically treated product being slower in rehydration was less hygroscop. So that it can be exposed to the atmosphere for several hours without becoming sticky (Ponting et al. 1966). The uptake of salt by the product showed a possible effect on the course of drying. The slices approached equilibrium rapidly and after 4 h of osmotic dehydration there was not much further concentrated effect on the slices. The uptake of salt consequently loss of water which occur in osmosis increased internal resistance to moisture movement. The drying rate decreased with increase in salt concentration. This may be due to the higher solids gain from salt containing osmosis solution. Similar trend has been reported by Islam and Flink (1982) in potato products treated with sucrose and salt.

The chemical composition of fresh and dehydrated onion slices used for experiment is given in Table 2 and for onion powder in Table 3. The moisture content slightly increased with increase in salt concentration (Table 3). This may be due to variation of rate of water removal and uptake of the salt by the slices at different concentrations before grinding into powder form. Loss of pungency had slightly occurred during osmotic dehydration with increase in salt concentrations. It may be attributed to the leaching of the acids from the product

TABLE 1. DRYING AND RECONSTITUTION RATIO OF DEHYDRATED ONION SLICES

Salt concentrations, %	Water loss during osmotic process, %	Drying ratio	Reconstitution ratio	
			Cold water (Ambient temperature	Hot water (70°C)
0	-	8.21:1	1:3.80	1:3.72
5	12.15	6.33:1	1:2.75	1:3.22
10	6.92	5.11:1	1:2.98	1:3.56
15	4.00	4.63:1	1:3.81	1:3.75
20	5.54	4.60:1	1:3.39	1:3.73

TABLE 2. CHEMICAL COMPOSITION OF FRESH AND DEHYDRATED ONION SLICES

Samples	Moisture, %	TSS, °Brix	*Acidity as pyruvic acid, %	*Reducing sugars, %	*Total sugars, %	*Drying ratio	*Reconstitution ratio
Fresh	86.5	8.00	3.33	19.50	48.89	-	-
Dehydrated	5.12	-	2.45	20.55	60.34	8.65:1	1:4.97

*Figures are on dry weight basis (d.w.b)

TABLE 3. PHYSICO-CHEMICAL COMPOSITION OF ONION POWDER

Parameters	Salt concentrations, %				
	0	5	10	15	20
Moisture, %	4.30	2.15	2.20	2.23	2.25
Acidity as pyruvic acid, %	3.30	3.30	3.28	3.24	3.25
Reducing sugars, %	17.05	18.61	17.33	17.10	16.73
Total sugars, %	43.62	42.11	41.58	41.47	41.42
NEB OD at 420 nm	0.361	0.093	0.092	0.090	0.091
Sensory evaluation	6.50	7.00	7.500	8.00	7.00

TABLE 4. EQUILIBRIUM RELATIVE HUMIDITY OF ONION POWDER AT ROOM TEMPERATURE (33-35°C)

Equilibrium moisture content, %	Equilibrium humidity, %	Days required to reach equilibrium	Remarks
1.18	10	30	Free flowing, colour normal, onion flavour
1.24	20	28	-do-
2.18	30	26	-do-
3.68	40	24	-do-
5.22	50	23	granulation, free flowing, normal colour
9.14	60	20	Colour faded, caking observed
14.47	70	18	Pasty consistency and slight darkening
21.94	80	14	Caky and mould affected after 17 days
31.23	90	9	Wet caky and mould growth appeared after 11 days
42.65	100	6	Mould growth appeared after 9 days

to the osmosis solution. The sugar content decreased with increased salt concentration. This may be attributed to leaching of sugars and acids and uptake of salt by the product with increase in concentration. The non-enzymatic browning decreased with increased salt concentration. This may be due to retardation of enzymatic and non-enzymatic browning reactions by the salt (Chaudhary et al. 1993).

The relationship between equilibrium moisture content, number of days taken by the product to reach equilibrium at a particular relative humidity and general condition of the product at different relative humidities are presented in Table 4, Mould growth (*Penicillium digitatum*) in the samples was observed at 80 % RH after 17 days of storage. The critical and danger points for the product was found to be at 9.14 % and 6.75 % moisture respectively. At higher RH, the product had a tendency to gain moisture and became caky and dark in colour while at lower RH, the moisture loss was more and the product remained free flowing.

The effect of packaging material on the quality and stability of onion powder in terms of changes in moisture,

TABLE 5. CHANGES IN CHEMICAL CONSTITUENTS OF ONION POWDER STORED AT ROOM TEMPERATURE. (d.w.b.)

Salt concentration,%	Storage period, months	Packing system	Moisture, %	Acidity as pyruvic acid, %	Reducing sugars, %	Total sugars, %	NEB O.D. at 420 nm
0	0	-	4.30	3.32	17.05	43.62	0.361
	6	200 g LDPE	6.58	3.18	18.70	44.05	1.82
		400 g LDPE	5.90	3.22	18.80	44.60	1.71
		200 g HDPE	5.75	3.28	19.22	43.62	1.58
5	0	-	2.15	3.30	18.61	42.11	0.093
	6	200 g LDPE	6.29	3.17	18.91	44.56	1.70
		400 g LDPE	5.89	3.28	18.52	43.64	1.59
		200 g HDPE	5.69	3.28	18.07	42.92	1.48
10	0	-	2.20	3.28	17.33	41.58	0.092
	6	200 g LDPE	3.58	3.23	18.61	46.57	1.76
		400 g LDPE	3.43	3.28	18.27	46.42	1.44
		200 g HDPE	3.33	3.26	18.25	46.28	1.03
15	0	-	2.23	3.24	17.10	41.47	0.090
	6	200 g LDPE	4.73	3.21	18.72	47.58	1.88
		400 g LDPE	3.54	3.22	18.58	47.28	1.34
		200 g HDPE	3.45	3.23	18.28	47.22	1.24
20	0	-	2.25	3.25	16.73	41.42	0.091
	6	200 g LDPE	3.53	3.21	16.91	46.28	1.55
		400 g LDPE	3.51	3.23	16.82	45.37	1.37
		200 g HDPE	3.41	3.23	16.81	45.28	1.20

g = Gauge, LDPE = Low density polyethylene, HDPE = High density polyethylene, NEB = Non enzymatic browning

TABLE 6. CHANGES IN CHEMICAL CONSTITUENTS OF ONION POWDER STORED AT LOW TEMPERATURE. (7°C) (d.w.b.)

Salt concentration,%	Storage period, months	Packing system	Moisture, %	Acidity as pyruvic acid, %	Reducing sugars, %	Total sugars, %	NEB O.D. at 420 nm
0	0	-	4.30	3.32	17.05	43.62	0.362
	6	200 g LDPE	5.21	3.10	18.60	44.92	1.80
		400 g LDPE	4.68	3.12	18.22	44.91	1.69
		200 g HDPE	4.52	3.18	18.12	44.81	1.55
5	0	-	2.15	3.30	18.61	42.11	0.093
	6	200 g LDPE	4.65	3.21	18.59	44.93	1.780
		400 g LDPE	4.51	3.24	18.22	44.84	1.67
		200 g HDPE	4.42	3.25	18.13	44.82	1.46
10	0	-	2.20	3.28	17.33	41.58	0.092
	6	200 g LDPE	3.29	3.23	18.60	46.87	1.75
		400 g LDPE	3.17	3.25	18.52	46.07	1.44
		200 g HDPE	3.14	3.25	18.50	46.01	1.03
15	0	-	2.23	3.24	17.10	41.47	0.090
	6	200 g LDPE	3.77	3.17	18.92	47.38	1.78
		400 g LDPE	3.75	3.18	18.28	47.27	1.35
		200 g HDPE	3.08	3.18	18.23	47.25	1.03
20	0	-	2.25	3.25	16.73	41.42	0.091
	6	200 g LDPE	3.50	3.22	17.58	46.19	1.75
		400 g LDPE	3.25	3.22	17.57	46.12	1.311
		200 g HDPE	3.10	3.24	17.36	46.10	1.03

g = Gauge, LDPE = Low density polyethylene, HDPE = High density polyethylene, NEB = Non enzymatic browning

acidity, sugar and non-enzymatic browning are given in Tables 5 and 6. It has been observed that there was continuous picking up of moisture by the product in all the samples during storage and it was found to be maximum during the initial period of storage. The gain of moisture was highest at ambient temperature as compared to low temperature. It may be due to more absorption of moisture from the atmosphere by the powder being hygroscope in nature. Similar trend was also described by Helkel et al (1972) in dried mango sheets. With regard to packaging material, the samples stored in higher gauge of polyethylene bags gained less moisture in all the conditions of storage as compared to lower gauge polyethylene. It may be due to lower permeability to water vapour at higher gauge. The loss of pungency (as acidity) was more in the samples stored at ambient temperature as compared to low temperature. This may be due to sensitivity of pungency constituents to higher temperature. In respect of packaging material, the retention of pungency was more in the samples packed in 200 gauge HDPE pouches followed by 400 and 200 gauge LDPE pouches. This may be due to gain of more moisture by the packages of lower gauge as compared to higher gauge packaging material. Reducing sugar content which is essential to maintain browning of dehydrated product was lower in the samples packed in higher gauge in comparison to lower gauge. This can be attributed to the high level of pungency and greater protection caused by the higher gauge packages. The non-enzymatic browning was more in 200 gauge LDPE pouches and least in 200 gauge HDPE pouches. This may be due to low moisture content in 200 gauge HDPE pouches, which helped to maintain the better colour of the product.

In respect of storage conditions the reducing and total sugars as well as non-enzymatic browning was higher in the samples stored at ambient temperature. This may be due to faster rate of chemical reactions at higher temperature as compared to low temperature. Hence the product should be stored at low temperature and higher gauges of pouches.

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RESEARCH NOTE

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Processing and Preservation of Jack Fruit (*Artocarpus heterophyllus* L.) Bar *(Thandra)*

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Jack fruit *thandra* (Bar) was prepared as per FPO specifications using two varieties of jack fruits and packed in butter paper (BP), polypropylene pouches (PP) and metallised polyester low density polyethylene laminate pouches (MPP) and stored at room temperature (30 - 36°C) for 6 months. The storage stability, microbiological and sensory changes were evaluated periodically during storage. The bar samples stored in MPP recorded higher percentage of nutrient retention and minimum microbial count than the samples in BP and PP at the end of 180 days. A reduction in vitamin C, β-carotene and total sugar contents were observed in the samples irrespective of the packaging materials. The sensory evaluation score values of the bar in MPP were found to be higher than by the samples in PP and BP in that order.

Keywords : Jack fruit bars, Storage stability, Packaging materials. Sensory qualities, Microbiological qualities, Room temperature.

Bar *(Thandra)* is an age old traditional fruit product (bar) accepted by all age groups (Nanjundaswamy et al. 1976; Rao and Roy 1980 a). *Thandra* is a semi-moist food which can be stored safely for longer time at room temperature in polyethylene pouches. In addition, it contains sufficient dissolved solutes to decrease water activity below that required to support microbial growth. Mango bar *(thandra)* has taken an important place in the commercial trade not only in India but in other countries too. Trials were conducted to develop fruit bar from single fruit (papaya) or in combination of two or more fruits (papaya, mango and pineapple). The present study was undertaken to develop bar *(thandra)* from jack fruit containing golden yellow colour, strong flavour, highly acceptable taste and to assess its storage stability in different packaging materials.

Mature ripe jack fruit of "local" (V_1) and "Vellipala" (V_2) varieties were procured from the local whole sale market. Sound bulbs (carpel) were separated from the fibrous mesocarp of each variety of jack fruit. Seeds were removed with seed coat from the carpel. The cleaned bulbs were cut into pieces, pulped in mixie and passed through a hand pulper.

Acidity and °Brix of the pulp were adjusted to 0.4% and 50°Brix, mixed, spread evenly on tray (26 x 18 cm) to a thickness of 1.00 cm and dried at 50° ± 2°C for 12 h by using cabinet drier. The proportion of ingredients was calculated for 10 kg of the pulp (CFTRI 1990). Jack fruit bar "Local" and "Vellipala" was prepared by dehydration method. The dried layer was cut into rectangular bar (9.0 x 2.6 x 1.0 cm) and packed individually (30 g) in butter paper, polypropylene pouches (PP) (250 μ, 15.5 x 10 cm) and metallised polyester (12 μ), low density polythelyne (48 μ), laminate pouches (MPP) and stored at room temperature. The method of preparation of bar is given in the flow diagram (Fig. 1).

The stored samples were analysed at monthly intervals for moisture, acidity, total and reducing sugars as per the method described by Ranganna (1995), pH and total ash by the method outlined by Hart and Fischer (1971), β-carotene by NIN procedure and ascorbic acid by the procedure described by Mahadevan and Sridhar (1982). While total soluble solids (TSS) were recorded using hand refractometer (Erma, Japan) ranging from 40 to 82° Brix. Microbial load (bacteria, fungi and yeast) was estimated in the stored jack fruit bar by the method described by Istavan Kiss (1984) at monthly intervals by adopting pour plate method using serial dilution technique. The sensory evaluation was done by 10 untrained judges using a 4-point Hedonic scale (CFTRI 1986) at an interval of 30 days. The mean data of the chemical constituents were statistically analysed by using Factorial Randomised Block Design (FRBD).

The changes in the chemical constituents of jack fruit bars as influenced by different packaging materials is presented in Table 1. The data for each chemical change was collected at

TABLE 1. CHANGES OF CHEMICAL CONSTITUENTS IN JACK FRUIT BAR DURING STORAGE (ON DRY WEIGHT BASIS)

Storage period, days	Packaging materials	Moisture		TSS, °Brix		Acidity, g%		pH*		Total sugars* g%		Reducing sugars, g%		Ascorbic acid*,g%		β-carotene, μg/100g*	
		V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
0	Initial	16.48	16.73	93.39	93.67	0.478	0.480	4.69	4.67	53.20	54.22	8.55	8.66	7.54	7.30	35.92	39.01
90	BP	16.37	16.57	93.26	93.49	0.497	0.503	4.60	4.59	51.90	53.79	8.90	8.85	6.79	6.15	23.91	29.96
	PP	16.42	16.66	93.36	93.60	0.496	0.507	4.62	4.59	52.42	53.86	8.65	8.78	6.86	6.30	26.92	32.37
	MPP	16.39	16.69	93.36	93.63	0.498	0.511	4.62	4.59	52.48	53.96	8.61	8.77	6.92	6.30	29.80	33.01
180	BP	15.86	15.92	92.70	92.77	0.547	0.557	4.51	4.50	51.90	53.21	9.09	9.18	4.75	4.67	18.06	20.40
	PP	16.39	16.45	93.33	93.36	0.553	0.565	4.51	4.51	52.42	53.35	8.95	9.03	7.96	5.00	20.93	22.44
	MPP	16.43	16.35	93.33	93.25	0.568	0.577	4.54	4.48	52.48	53.37	8.77	8.95	5.00	5.02	23.03	23.31
SED		0.00667		0.16846		0.00065		0.00667		0.00667		0.00801		0.05427		0.00667	
CD (1%)		0.1876		0.47379		0.00182		0.01875		0.01875		0.02253		0.15265		0.01875	

* *Corresponding Author*

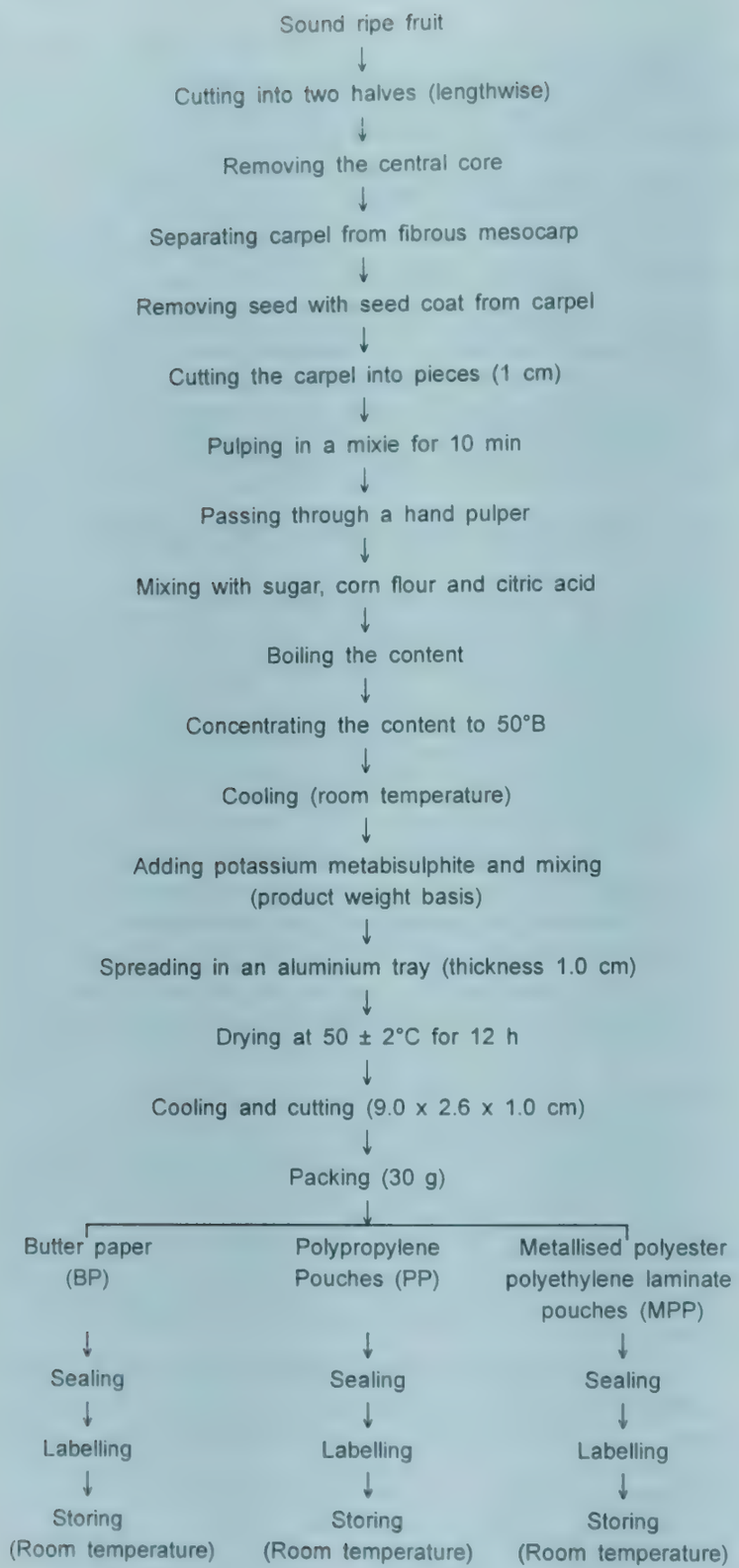
Sound ripe fruit
Cutting into two halves (lengthwise)
Removing the central core
Separating carpel from fibrous mesocarp
Removing seed with seed coat from carpel
Cutting the carpel into pieces (1 cm)
Pulping in a mixie for 10 min
Passing through a hand pulper
Mixing with sugar, corn flour and citric acid
Boiling the content
Concentrating the content to 50°B
Cooling (room temperature)
Adding potassium metabisulphite and mixing (product weight basis)
Spreading in an aluminium tray (thickness 1.0 cm)
Drying at 50 ± 2°C for 12 h
Cooling and cutting (9.0 x 2.6 x 1.0 cm)
Packing (30 g)
Butter paper (BP)
Polypropylene Pouches (PP)
Metallised polyester polyethylene laminate pouches (MPP)
Sealing
Labelling
Storing (Room temperature)

Fig. 1. Flow chart for preparation of jack fruit bar

each month. But for the discussion, the initial, 90 and 180 days of storage have been taken. Moisture content of the samples of both the varieties were decreased with storage period. It was observed from the results that the samples packed in butter paper showed higher moisture loss (3.76%), followed by the samples of local variety packed in PP (0.55%) and MPP (0.18%) pouches. The loss may be attributed to evaporation of water from bar due to higher storage temperature similar to that the moisture content of papaya bar decreased significantly during storage (Rao and Roy 1980 a). TSS of bar samples showed slight decrease in all the packaging materials. The significant increase in total acids can be attributed to loss of moisture, resulting in the concentration of the product during storage (Nanjundaswamy et al. 1976; Rao and Roy 1980 b; Mir and Nath 1993).

Acidity of the bars of both varieties increased while pH decreased during storage. Among the packaging materials, the bar samples stored in MPP pouches had recorded higher acidity followed by PP and BP. Doreyappa Gowda et al (1995) reported an increase in acidity of mango bar from 1.4 – 1.5% after six months. A significant decrease in total sugar content of jack fruit bar might be due to an increase in reducing sugars by acid hydrolysis of total sugars and thereby inversion of total sugars. The per cent loss of total sugar was high in the samples of BP than PP and MPP pouches. Similar pattern of decreasing trend was reported by Doreyappa Gowda et al (1995). Reducing sugars exhibited an increasing trend in the bar samples during storage. Jack fruit bar samples packed in BP had slightly higher reducing sugar content followed by PP and MPP pouches after storing for 180 days at room temperature. Similar trend in the reducing sugar content of mango and papaya bars were observed by Rao and Roy (1980 a) and Aruna et al (1999), respectively.

A significant remarkable reduction was noted in ascorbic acid and β-carotene contents of samples during storage. The maximum retention of β-carotene and ascorbic acid were found in the samples of MPP pouches. Average ascorbic acid loss and β-carotene loss of local variety at room temperature after 180 days storage were 35.01 and 42.45%, respectively. Among the packaging materials, MPP and PP pouches were better compared to BP in retaining ascorbic acid and β-carotene during storage. Bars from the "Vellipala" jack fruit contained more β-carotene than "Local" variety. Gahilad et al (1982) reported that mango leather packed in polyethylene bags showed a reduction in both ascorbic acid and β-carotene contents after storing for 70 days at 10 ± 1°C. Statistical analysis of the data for acidity, pH, total and reducing sugars, ascorbic acid and β-carotene contents of bar samples showed significant differences between varieties and packaging materials throughout the storage period.

The bacteria, fungi and yeast population enumerated during storage is presented in Table 2. The microbial counts of bars packed in various packaging materials was nil at initially and increased slightly during storage. No microorganism was traceable initially due to the higher dilution used for the enumeration. Jack fruit bar samples in MPP pouches showed minimum of microbial counts than samples in PP pouches and butter paper. Samples packed in BP exhibited slightly higher microbial population than the rest of the samples. In general, the microbial population of the samples prepared for the study showed only a minimum microbial count at the end of 180 days of storage. The preservative (KMS) added, while preparing the bars, might have prevented the growth of microbes.

The sensory scores for jack fruit bars during storage are given in Table 3. The results of sensory evaluation showed that the sensory attributes like colour, flavour, texture and taste of the samples of the "Local" and the "Vellipala" jack fruit varieties

TABLE 2. MICROBIAL POPULATION OF JACK FRUIT BARS DURING STORAGE

Storage period, days	Variety	Bacteria			Fungi			Yeast		
		BP	PP	MPP	BP	PP	MPP	BP	PP	MPP
0	V_1 & V_2	0	0	0	0	0	0	0	0	0
90	V_1	3	2	3	2	2	2	1	1	1
	V_2	3	2	2	2	2	2	1	1	1
180	V_1	6	5	4	4	4	3	4	3	3
	V_2	6	5	5	4	4	3	3	3	2

TABLE 3. SENSORY SCORES FOR JACK FRUIT BARS DURING STORAGE

Storage period, days	Variety	Colour			Flavour			Texture			Taste			Overall acceptability		
		BP	PP	MPP	BP	PP	MPP	BP	PP	MPP	BP	PP	MPP	BP	PP	MPP
0	V_1 & V_2	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
90	V_1	3.8	3.8	4.0	3.9	4.0	4.0	3.8	4.0	4.0	3.8	3.9	4.0	3.8	3.9	4.0
	V_2	3.9	4.0	4.0	3.9	4.0	4.0	3.9	4.0	4.0	3.9	4.0	4.0	3.9	3.9	4.0
180	V_1	3.5	3.6	3.7	3.5	3.7	3.7	3.6	3.7	3.7	3.6	3.7	3.8	3.5	3.7	3.8
	V_2	3.5	3.6	3.8	3.6	3.7	3.8	3.6	3.8	3.9	3.7	3.8	3.9	3.6	3.7	3.9

in PP and MPP pouches were most acceptable upto 90 days of storage at room temperature. Natural flavour of bars was maintained upto 90 days except in BP samples of both varieties. The freshly prepared bar samples had firm texture which had changed to mild to moderate hardness during storage. A highly acceptable score value for texture and taste was observed in the samples of the "Local" and the "Vellipala" jack fruit varieties packed in PP and MPP pouches probably because of moisture retention. The overall acceptability of bar samples indicated that products packed in PP and MPP pouches were more acceptable than samples in BP. The results have indicated that "Vellipala" variety could retain higher percentage of nutrients and ranked high specially packed in MPP.

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Factors Affecting Protein Extraction from Cowpea

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Cowpea proteins were extracted using distilled water or ordinary tap water or sodium chloride (NaCl) (0.5 or 1.0 M), at varied extraction times and flour to solvent ratios. Maximum protein extractability was 81% for distilled and tap water, 76.4 and 78.1% for 0.5 and 1.0 M NaCl, respectively. Optimum extraction time varied with solvent nature; it was 30 min for water and 150 min for NaCl, when the flour to solvent ratio was maintained at 1:25. The nitrogen solubility for cowpea proteins was 94.8% at pH 11 and 56% at pH 1. The minimum nitrogen solubility of 11% was obtained at pH 4. The total protein content of cowpea was found to be 26.0%

Keywords : Cowpea, Protein, Extraction, Water.

Cowpea is the principal source of dietary protein in West Africa, South America, India and other tropical countries. Traditionally, leguminous seeds play only a small role in the Sudanese diet. In Sudan, cowpea-based food products are utilized as weaning foods for infants. Cowpea protein concentrates could be utilized in the production of several conventional food formulations to increase their protein content as well as in the production of textured foods.

The objective of this study was to standardize optimum conditions for the extraction of cowpea proteins.

Cowpea *(Vigna unguiculata* L. *walp)* grains were purchased from Omdurman local market (Sudan). The samples were cleaned and freed from foreign materials, followed by milling in a mechanical grinder to pass through 0.8 mesh screen.

Protein was extracted from cowpea by Sefa-Deddah and Stanley (1970) method; using tap water, distilled water or NaCl (0.5 or 1.0 M) for 30, 60, 90, 120 or 150 min at different flour to solvent ratios i.e. 1:25, 1:20, 1:15 or 1:10. The protein in the extract was determined using micro-Kjeldahl method (AOAC 1984). Nitrogen solubility was determined over pH range of 1-12 by procedure of Hagemaier (1972) as modified by Quinn and Beuchat (1975).

When water was used for protein extraction the extractability decreased, as extraction time increased, minimum extraction of 18.7% and 28.4% for tap water and distilled water, respectively occurred at 150 min (Table 1). Using a fixed time (30 min), nitrogen extractability decreased by increasing flour to solvent ratio for both tap water and distilled water. Lowest extraction occurred at 1:10 flour to solvent ratio (Table 2). Minimum extraction percentages for both salt concentrations (0.5 and 1.0 M) were 63.8 and 66.8, respectively occurring at 30 min extraction time; while maximum percentages of 76.4 and 78.1 were found at 150 min extraction time (Table 1). These results were similar to those of Smith et al (1959) who obtained 72.3, 76.2 and 79.1% of extraction from soybean, kidneybean and mungbean, respectively.

Evans and Kerr (1963) reported that increasing salt concentration from 0.19 M to 1.52 M extracted similar amount of nitrogen (74-76%). Increasing flour to solvent ratio from 1:25 to 1:10 gave inverse relation to the efficiency of protein extraction (Table 2). Percentage of protein extracted at 1:25 was 76.4, while a value of 78.1 was obtained for 0.5 and 1.0 M NaCl, respectively. These values were significantly different from those obtained for extraction with higher flour to solvent ratios.

The solubility of cowpea nitrogen was shown to be highly pH dependent. The proteins were highly solubilized (94.8%) in alkaline pH (pH 11) as reported by Quinn and Beuchat (1975) and Smith et al (1959). The pH of minimum protein solubility (11%) was found at pH 4 in the isoelectric zone (Fig. 1) which

TABLE 1. EXTRACTABILITY OF COWPEA PROTEINS* AT DIFFERENT EXTRACTION TIMES WITH DIFFERENT SOLVENTS (FLOUR TO SOLVENT RATIO 1:25)

Time, min	Tap water	Distilled water	NaCl 0.5 M	NaCl 1.0 M
	Protein extracted, %			
30	81.2 (±0.18)^a	80.7 (±0.35)^a	63.8 (±1.6)^a	66.8 (±0.00)^a
60	74.4 (±2.8)^b	74.0 (±0.48)^b	67.3 (±0.09)^b	66.8 (±0.35)^b
90	27.1 (±1.14)^c	54.8 (±1.05)^c	74.0 (±0.02)^c	74.0 (±0.02)^c
120	20.1 (±1.03)^d	43.0 (±1.6)^d	75.5 (±1.40)^e	76.1 (±0.60)^d
150	18.8 (±1.7)^d	28.4 (±1.5)^e	76.4 (±2.20)^d	78.1 (±0.21)^e

Values are means (±SD)
Means not sharing a common superscript letter in a column are significantly different at p≤0.05 as assessed by Duncan's Multiple Range Test.
* Protein content of cowpea 26.0%

TABLE 2. EXTRACTABILITY OF COWPEA PROTEIN AT DIFFERENT FLOUR TO SOLVENT RATIOS WITH DIFFERENT SOLVENTS (EXTRACTION TIME : 30 MIN)

Flour to solvent ratio	Tap water	Distilled water	NaCl 0.5 M	NaCl 1.0 M
	Protein extracted, %			
1:25	80.2 (±0.18)^a	81.2 (±0.35)^a	63.8 (±1.60)^a	66.8 (±0.01)^a
1:20	75.5 (±1.06)^b	80.0 (±0.35)^a	57.8 (±1.10)^b	65.4 (±0.60)^a
1:15	39.8 (±2.6)^c	35.8 (±0.8)^b	45.4 (±0.80)^c	61.4 (±1.10)^b
1:10	17.2 (±2.2)^d	25.1 (±1.2)^c	34.9 (±0.09)^d	40.6 (±0.10)^c

Values are means (±SD)

* Corresponding Author

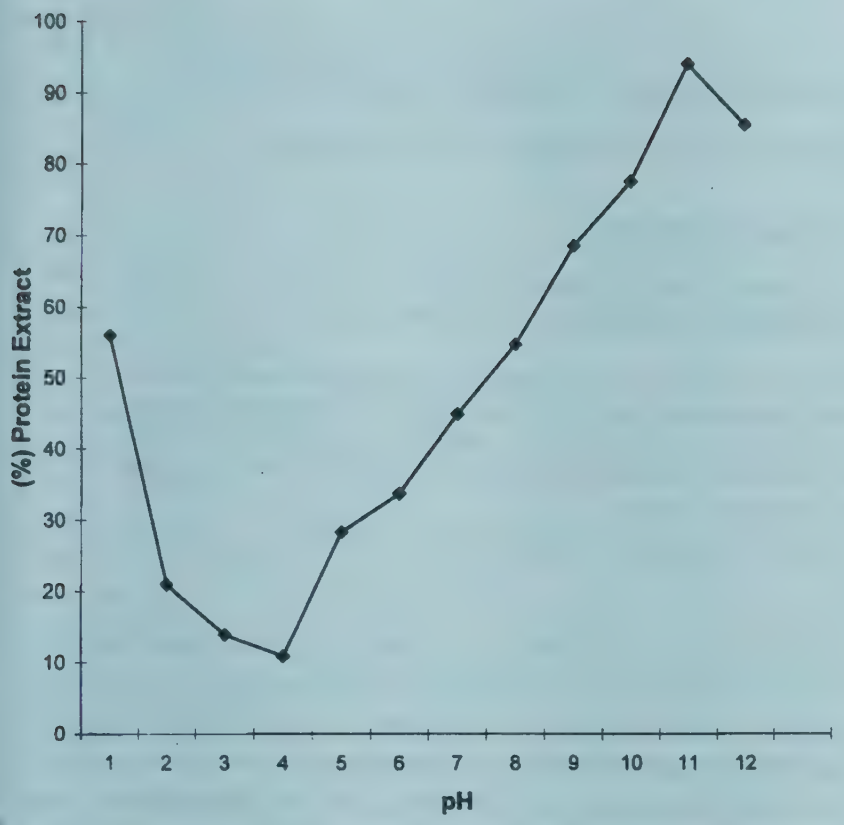

Fig. 1. Effect of pH on the extractability of cowpea proteins

was attributed to increased intermolecular attraction in this region (Molina et al 1974). Solubility of cowpea nitrogen at acidic pH (1.0) was found to be 56.0% (Fig. 1); at low pH values, the proteins are positively charged and redissolved. Bressani and Elias (1974) and Okaka and Potter (1977) reported similar results on the solubility of cowpea proteins at different pHs.

It may be concluded that optimum conditions for extraction of cowpea protein were found to be 30 min extraction time for tap and distilled water as solvent, while using salt solutions (NaCl) the optimum extraction time was 150 min. Optimum flour to solvent ratio for tap and distilled water as well as salt solutions was 1:25.

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Proximate Composition of Non-traditional Leafy Vegetables in Nellore and Prakasam Districts of Andhra Pradesh

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The non-traditional leafy vegetables, which were grown in and around the field, near canals and waste lands were collected from Nellore and Prakasam districts of Andhra Pradesh and the proximate composition was estimated as per standard procedures. Analytical data of ten selected non-traditional leaves revealed that they were good sources of moisture, proteins, crude fibre, β-carotene and ascorbic acid. The selected leaves had lower amounts of fat and moderate amounts of oxalic acid. The data on proximate composition revealed that they had promising nutritive value and were nutritionally good.

Keywords : Non-traditional leaves, Leafy vegetables, Proximate composition, Oxalic acid, Vitamins.

Non-traditional leafy vegetables are seldom used by our population. Generally, the poor and the tribals prefer to include them in their diets, while the people from urban and well-to-do families do not. Even the people, who are the major consumers of the non-traditional leaves are not utilising them to the maximum extent. Consumption of indigenous green leafy vegetables has its effects on increasing dietary intakes of iron and pro-vitamins, as well as other minerals and vitamins (Yang 1979). In this study, proximate composition of ten non-traditional leafy vegetables was determined and the results are reported.

The non-traditional leaves viz., Chenchalaku *(Digera arvensis)*, elukajemudaku *(Merremia emarginata)*, avisaku *(Sesbania grandiflora)*, gurugaku *(Celosia argentia)*, duradagundaku *(Ischnemone indica)*, thummikura *(Lucas aspera)*, payilaku *(Trianthema portulacastrum)*, atikamamidi *(Boerhavia diffusa)*, boddaku *(Tinospora cordifolia)* and pippintaku *(Acalypha indica)* are grown in and around the fields, near canals and waste lands and edible portions (Table 1) collected from Nellore and Prakasam districts of Andhra Pradesh.

Moisture, total carotenes, β-carotene and ascorbic acid were estimated on fresh weight basis. The samples were dried and powdered in a grinder. The dried samples were analysed for proteins, fat, ash, crude fibre and oxalic acid on dry weight basis and expressed on fresh weight basis.

Moisture (AOAC 1990), protein (AOAC 1984), fat (AOCS 1981), ash (AOAC 1984), crude fibre (NIN 1983), ascorbic acid (Freed 1947), total carotenes and β-carotenes (Zakaria et al. 1976) were estimated and expressed on fresh weight basis. Oxalic acid was determined by the method of Baker (1952).

Moisture : The moisture content (Tables 1, 2) of the leafy vegetables ranged from 60.99 g/100 g to 90.17 g/100 g, the highest being in *Payilak* (90.17 g/100 g). *Elukajemudaku, avisaku* and *thummikura* showed comparitively low moisture content. The lowest moisture content (69.60 g/100 g) was observed in *duradagundaku*.

Proteins : The highest protein content (6.89 g/100 g) was observed in *duradagundaku* and the lowest (2.17 g/100 g), in *payilaku* on fresh weight basis (Table 1). Leafy vegetables were, generally, poor sources of protein as they contain less than 2.00% proteins (Gopalan et al. 1996). But, the selected non-traditional leaves had more than 2.00% proteins. Some earlier workers had also reported more than 2.00% of protein content regarding other uncommon leaves (Shingade and Chavan 1995; Tamilarasi Murugesan and Anantha Lakshmi 1991). From Table 2, it can be seen that the protein content ranged from 21.70 g/100 g *(Avisaku)* to 33.44 g/100 g *(Atikamamidi)* on dry weight basis.

Fat : The fat content (0.48 g/100 g – 1.57 g/100 g) (Table 1) of the selected leaves on fresh weight basis was low and was comparable with the common leaves estimated on fresh weight basis (Gopalan et al. 1996). The highest fat content (1.57 g/100 g) was observed in *thummikura* and the lowest (0.48 g/100 g) in *atikamamidi* on fresh weight basis. The fat content ranged from 2.85 g/100 g *(atikamamidi)* to 6.52 g/100 g *(Duradagundaku)* on dry weight basis (Table 2).

Ash : The lowest value of ash was observed in *chenchalaku* (1.78 g/100 g) and the highest value in *duradagundaku* (3.50 g/100 g) (Table 1) on fresh weight basis. More than 2 g/100 g of ash content was observed in all the selected leaves except *chenchalaku* (1.78 g/100 g). The ash content on dry weight basis varied from 8.32 g/100 g *(avisaku)* to 29.91 g/100 g *(gurugaku)* (Table 2).

Crude fibre : The selected leaves had more than 1.00% crude fibre on fresh weight basis except *chenchalaku* (0.58 g/100 g), the highest being in *thummikura* (2.69 g/100 g) (Table 1). Similarly, the unconventional leafy vegetables from the konkan region of Maharashtra contain more than 1.00% crude fibre except spinach (0.7%) (Shingade and Chavan 1995). The crude fibre on dry weight basis varied from 4.75 g/100 g *(avisaku)* to 14.53 g/100 g *(payilaku) (Table 2)*.

Vitamins : The total carotenes of the selected leaves varied from 11.73 mg/100 g *(payilaku)* to 37.41 mg/100 g *(duradagundaku)* and the β-carotene ranged from 3.90 mg/100 g *(thummikura)* to 17.05 mg/100 g *(duradagundaku)*. The ascorbic acid content among the leaves varied from 22.24 mg/100 g *(gurugaku)* to 119.06 mg/100 g *(pippintaku)* (Table 1).

Oxalic acid : Oxalic acid, a dicarboxylic acid or its salts (oxalates) were widely distributed in plant foods (Gopalan et al. 1996). *Duradagundaku* (390.34 mg/100 g) and *thummikura*

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TABLE 1. PROXIMATE COMPOSITION OF NON-TRADITIONAL LEAFY VEGETABLES ON FRESH WEIGHT BASIS PER 100 G EDIBLE PORTION

Non-traditional leafy vegetables	Moisture, g	Proteins, g	Fat, g	Crude fibre, g	Ash content, g	Total carotenes mg	Vitamins β-carotene, mg	Ascorbic, acid, mg	Oxalic acid, mg
Chenchalaku *(Digera arvensis)*	89.79 ± 3.40	2.72 ± 0.18	0.49 ± 0.06	0.58 ± 0.82	1.78 ± 0.02	47.08 ± 1.08	16.66 ± 0.24	105.02 ± 0.41	113.04 ± 0.29
Elukajemudaku *(Merremia emarginata)*	75.21 ± 4.06	5.38 ± 0.37	1.54 ± 1.29	1.33 ± 0.12	2.76 ± 0.52	32.72 ± 0.56	10.32 ± 0.13	55.29 ± 0.56	184.14 ± 1.08
Avisaku *(Sesbania grandiflora)*	72.90 ± 0.95	5.87 ± 0.28	0.87 ± 0.12	1.28 ± 0.32	2.26 ± 0.24	32.05 ± 0.78	11.90 ± 0.72	151.91 ± 0.84	147.92 ± 1.13
Gurugaku *(Celosia argentia)*	84.68 ± 2.14	3.31 ± 0.45	0.93 ± 0.02	1.32 ± 0.24	4.56 ± 0.64	15.37 ± 0.50	4.61 ± 0.52	22.24 ± 0.72	112.33 ± 0.04
Duradagundaku *(Ischnemone indica)*	69.60 ± 1.05	6.89 ± 0.16	1.23 ± 0.43	2.03 ± 0.21	3.50 ± 0.23	37.41 ± 0.65	17.05 ± 0.53	33.27 ± 1.00	390.34 ± 2.45
Thummikura *(Lucas aspera)*	73.90 ± 1.77	5.50 ± 0.34	1.57 ± 0.03	2.69 ± 0.17	3.44 ± 0.16	12.19 ± 0.67	3.90 ± 0.58	80.02 ± 0.47	355.81 ± 0.69
Payilaku *(Trianthema portula-castrum)*	90.17 ± 0.69	2.17 ± 0.15	0.55 ± 0.09	1.43 ± 0.14	2.18 ± 0.05	11.73 ± 0.38	5.76 ± 0.78	97.64 ± 0.74	148.08 ± 0.08
Atikamamidi *(Boerhavia diffusa)*	82.28 ± 1.07	5.93 ± 0.12	0.48 ± 0.12	1.20 ± 0.25	3.27 ± 0.11	15.17 ± 0.78	6.10 ± 0.16	29.02 ± 0.09	97.47 ± 0.18
Boddaku *(Tinospora cordifolia)*	78.48 ± 0.32	6.22 ± 0.39	0.85 ± 0.23	2.11 ± 1.66	2.57 ± 0.29	15.91 ± 0.33	5.20 ± 0.86	30.56 ± 0.62	200.37 ± 0.14
Pippintaku *(Acalypha indica)*	79.15 ± 0.55	6.00 ± 0.22	1.19 ± 0.15	1.86 ± 0.26	2.48 ± 0.09	33.31 ± 0.74	10.81 ± 0.59	119.06 ± 0.53	58.25 ± 0.35

TABLE 2. PROXIMATE COMPOSITION OF NON-TRADITIONAL LEAFY VEGETABLES ON DRY WEIGHT BASIS PER 100 G EDIBLE PORTION

Non-traditional leafy vegetables	Moisture, g	Proteins, g	Fat, g	Crude fibre, g	Ash content, g	Oxalic acid, mg
Chenchalaku *(Digera arvensis)*	89.79 ± 3.40	27.08 ± 2.68	4.76 ± 0.60	5.69 ± 1.67	17.39 ± 1.20	1106.77 ± 3.30
Elukajemudaku *(Merremia emarginata)*	75.21 ± 4.06	21.73 ± 0.48	6.21 ± 0.89	5.37 ± 0.18	11.13 ± 2.04	742.78 ± 4.36
Avisaku *(Sesbania grandiflora)*	72.90 ± 0.95	21.70 ± 0.48	3.19 ± 0.44	4.75 ± 1.13	8.32 ± 0.97	547.02 ± 4.18
Gurugaku *(Celosia argentia)*	84.68 ± 2.14	23.14 ± 1.18	6.03 ± 0.09	8.57 ± 1.56	29.91 ± 4.07	734.24 ± 1.23
Duradagundaku *(Ischnemone indica)*	69.60 ± 1.05	22.65 ± 0.54	6.52 ± 0.53	6.66 ± 0.71	12.60 ± 0.71	1284.02 ± 8.06
Thummikura *(Lucas aspera)*	73.90 ± 1.77	21.83 ± 2.11	6.00 ± 0.11	10.32 ± 0.21	13.19 ± 0.68	1363.24 ± 2.64
Payilaku *(Trianthema portulacastrum)*	90.17 ± 0.69	21.99 ± 1.18	5.55 ± 0.43	14.53 ± 0.84	21.60 ± 1.20	1475.90 ± 2.23
Atikamamidi *(Boerhavia diffusa)*	82.28 ± 1.07	33.44 ± 0.60	2.85 ± 0.85	6.75 ± 1.37	18.16 ± 0.48	550.05 ± 1.02
Boddaku *(Tinospora cordifolia)*	78.48 ± 0.32	28.70 ± 1.57	3.84 ± 1.01	11.62 ± 0.74	11.91 ± 1.44	931.10 ± 0.67
Pippintaku *(Acalypha indica)*	79.15 ± 0.55	28.76 ± 1.11	5.71 ± 0.10	8.80 ± 1.25	11.89 ± 0.60	279.56 ± 1.77

(355.81 mg/100 g) had higher amounts of oxalic acid and the lower amounts of oxalic acid were found in *atikamamidi* (97.47 mg/100 g) and *pippintaku* (58.25 mg/100 g) (Table 1) on fresh weight basis. On dry weight basis (Table 2), it ranged from 279.56 mg/100 g *pippintaku* to 1475.90 mg/100 g *(payilaku)*.

The proximate composition estimated on the selected non-traditional leafy vegetables revealed that they had promising nutritive value and were nutritionally good. The consumption may be encouraged by organising intensive nutrition education programmes.

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RESEARCH NOTE

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Differentiation between Fresh and Frozen-thawed Pork

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Attempts were made to differentiate fresh pork muscles from those which have been frozen and thawed by estimation of the released lysosomal and mitochnodrial enzymes into the cell sap. Ham portion of pork was frozen at –18°C for three months and thawed at refrigerated (4°C) and room temperatures (25°C). The specific activities of acid phosphatase (ACP), alkaline phosphatase (ALP), glutamate oxaloacetate transaminase (GOT) glutamase pyruvate transaminase (GPT) lipoamide dehydrogenase (LPDH), lactate dehydrogenase (LDH) and succinate dehydrogenase (SDH) were determined in the muscle press juice of the intact tissue at 0, 7, 15, 30, 60 and 90 days interval. At the end of storage period (3 months), ACP activity increased significantly ($P<0.05$). The maximum release of GOT was observed after one month. The specific activity of LPDH and LDH also showed a significant ($P<0.05$) increase as a result of freezing and thawing. The SDH activity in frozen-thawed sample almost doubled upto two months of storage period as compared to fresh one. Increase in activities of these enzymes in muscle press juice may be suggestive to differentiate thawed from fresh pork.

Keywords : Pork, Freezing, Thawing, Lysosomal, Mitochondrial, Enzymes.

Freezing is one of the methods used by the meat industry to prolong the shelf life of meat, but fresh products are usually sold at higher prices than frozen ones. As a consequence, meat inspection authorities need analytical methods to differentiate fresh from thawed meat in the market. The process of freezing animal tissue leads to the disruption of cellular organelles like mitochondria, lysosomes etc. releasing into the cell sap the enzymes bound to these structures.

The activity of lysosomal enzymes in the centrifuged tissue fluid has been used to differentiate frozen from fresh fish (Shimomura et al. 1987; Kitamikado et al. 1990; Nilsson and Ekstrand 1993, 1995). Various methods have also been proposed for distinguishing fresh from frozen-thawed meat based on the release of mitochondrial/lysosomal enzymes into the sarcoplasm as a result of freezing and thawing in bovine (Hamm and El-Badawi 1984; Hamm and Gottesmann 1985; Chen et al. 1988; Balzaretti et al. 1992), pork (Demmer and Werkmeister, 1985; Toldra et al. 1991) and chicken muscles (Gottesman and Hamm 1984); Sen and Sharma 1998; Sharma and Sen 1998).

The present study was undertaken to determine the effects of frozen storage time, in combination with different thawing treatments, on pork muscle based on lysosomal as well as mitochondrial enzymes.

Meat samples : Ham was obtained from local meat shop within 60 min of slaughter. The meat was packed in low-density polythylene bags and brought to the laboratory in ice containers.

Freezing and frozen storage : Meat samples were frozen at –18°C and kept for 7, 15, 30, 60 and 90 days.

Thawing : Two thawing treatments were applied to frozen-stored samples by varying thawing temperature and time. First batch was thawed for 24 h at refrigerated temperature (4 ± 1°C) (T_F) and second one for 6 h at 25°C in an incubater (T_R) and refrozen for the above mentioned interval.

Muscle press juice : For the preparation of press juice, slices of the muscle were cut from the fresh and frozenthawed samples and centrifuged at 5°C at 18,000 rpm for 30 min (Sorvall RC5B, Rotor SS34). The fluid was collected with a Pasteur pipette for determination of volume, protein concentration and enzyme activity.

Protein determination : Protein content was determined by the biuret method as described by Delory (1966). Standard reading was taken using bovine serum albumin. All determinations were carried out in duplicate tubes.

Enzyme assay : Acid phosphatase (ACP) activity was estimated according to the method of Varley (1975 a). ACP hydrolyzes disodium phenyl phosphate to phenol and disodium phosphate. The phenol so formed, reacts with 4-amminoantipyrine in alkaline medium to form a red coloured complex whose absorbance is proportional to the enzyme activity. The activity of alkaline phosphatase (ALP) was determined as per Varley (1975 b) similarly by measuring absorbance on spectrophotometer at 510 nm. Specific activity of ACP and ALP was expressed as μ moles paranitrophenyl produced/min/mg protein.

Glutamate oxaloacetate transaminase (GOT) and Glutamate pyruvate transaminase (GPT) activities were determined as described by Reitman and Frankel (1957). A standard curve was drawn by using different concentrations of standard solution of sodium pyruvate (2 mM). Specific activity of GOT and GPT was expressed as μ moles pyruvate produced/min/mg protein.

The activity of lipoamide dehydrogenase (LPDH) was estimated according to the method of Bergmeyer (1974) and expressed as change in absorbance/min/mg protein. The assay mixture containing 2 ml phosphate buffer (0.1 M, pH 5.9), 0.1 ml EDTA (10 mg/ml), 0.5 ml DL-Dithio-n-actanoic acid (lipoic acid - 15 mg/ml, pH 7), 0.2 ml serum albumin (10 mg/ml), 0.5 ml NADH, Na salt (10 mg/ml) and 0.3 ml sample. After thorough mixing, absorbance was recorded at 340 nm on uv spectrophotometer (GBC, UV/VIS) at 15 sec interval against blank reagent. Lactate dehydrogenase (LDH) activity was estimated according to the procedure described by Vassult (1983). Tris/NaCl/NADH-2.5 ml and sample 0.3 ml was taken in a pipette and after mixing thoroughly, Tris/NaCl/pyruvat-0.5 ml was added. The specific activity was expressed as change in absorbance/min/mg protein. The activity of succinate dehydrogenase (SDH) was estimated by the method of Hazel (1972) with modification as follows : Assay mixture contained

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0.4 ml phosphate buffer (3.75 mM, pH 8), 0.5 ml sodium succinate solution (0.24 M), 0.4 ml EDTA solution (3.75 mM), 0.4 ml KCN (6 mM) and 0.5 ml sample. The assay mixture was preincubated for 10 min at 37°C followed by transfer in ice bath for 5 min. Thereafter, 0.45 ml dichlorophenol indophenol (0.42 mM) and 0.4 ml phenazine methosulphate (8.55 mM) were added. The change in absorbance at 600 nm was read at 15 sec interval against distilled water. Specific activity of SDH was expressed as change in absorbance/min/mg protein.

Statistical analysis : Three trials were conducted and statistical analysis was performed as per Snedecor and Cochran (1980).

It is evident from Table 1 that irrespective of thawing method, the percentage of the initial weight of the muscles which can be expressed as juice is enhanced following freezing and thawing. Jalang'o et al (1987) also reported increased press juice due to freezing and thawing in porcine muscle. This may be attributed to changes in the gross structure, some mechanical damage of cell walls and a limited denaturation of proteins by the raised ion concentration during freezing contributing to loss of water holding capacity. However, there was no pronounced variation in the protein content of centrifuged tissue fluid of fresh and frozen-thawed porcine muscles.

Activities of ACP and ALP were measured in press juice as an index of membrane disintegration occurring in procine muscle due to frozen storage conditions and different thawing treatments. Table 2 shows the ACP and ALP activity in porcine muscle after different periods of frozen-storage. By the end of storage period (3 months) ACP activity increased significantly ($P<0.05$). Freezing and thawing also caused a significant increase in ALP activity. A significant increase in ACP activity with elapsed storage period was also noticed by Nilsson and Ekstrand (1993) in thawed fish. However, thawing method did not influence the membrane integrity during frozen storage condition.

Table 3 shows the GOT and GPT activities in porcine muscle after different periods of freezing. The maximum release of GOT was observed after one month. But the relative increase for each storage period was not pronounced. The specific activity of GPT in frozen samples is significantly higher than that obtained in fresh samples. The maximum activity was observed after 15 days of storage and then remained constant for three months of frozen storage. The release of mitochondria bound enzymes by freezing and thawing was probably due to damage of the lipo-proteins of mitochondrial membranes.

The specific activity of LPDH showed a significant ($P<0.05$) increase (Table 4) due to freezing and thawing. Similar findings were also reported by Gottesmann and Hamm (1985) in chicken and sheep muscles. The slow thawing at refrigerated temperature (5°C) resulted in higher activity of these enzymes as compared to fast thawed (25°C) one. Nilsson and Ekstrand (1995) also reported that fast thawing preserved the membrane integrity more than slow thawing. The maximum of LPDH activity in the muscle press juice was reached after one month of frozen storage. The release of LDH also showed significant ($P<0.05$) increase with the storage period until 60 days. The SDH activity (Table 4) in frozen-thawed sample almost doubled upto two months of storage period as compared to the fresh one and tripled in three months of storage period.

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TABLE 1. INFLUENCE OF FREEZING AND THAWING OF MUSCLE TISSUE (PIG) ON PRESS JUICE (% WEIGHT) AND ITS PROTEIN CONTENT (GM%) (MEAN ± SE)

Days	Press juice			Proteins		
	T_F	T_R	Overall	T_F	T_R	Overall
0	13.84 ± 2.08	13.84 ± 2.08	13.84 ± 1.32	12.59 ± 0.19	12.59 ± 0.19	12.59^{a} ± 0.12
7	15.85 ± 0.72	16.22 ± 0.89	16.04 ± 0.52	12.18 ± 0.22	12.84 ± 0.26	12.51^{a} ± 0.21
15	15.44 ± 0.84	17.12 ± 0.88	16.28 ± 0.66	9.91 ± 0.98	12.69 ± 0.80	11.30^{ad} ± 0.84
30	17.43 ± 2.03	17.08 ± 1.48	17.25 ± 1.13	10.39 ± 0.70	12.62 ± 0.15	11.51^{ac} ± 0.59
60	16.25 ± 1.01	18.05 ± 1.16	17.15 ± 0.79	10.90 ± 0.91	10.34 ± 0.98	10.62^{bcd} ± 0.61
90	17.95 ± 1.06	16.77 ± 1.53	17.36 ± 0.87	9.51 ± 0.30	10.53 ± 0.90	10.02^{bd} ± 0.48
Overall	16.13 ± 0.58	16.52 ± 0.57	16.32 ± 0.40	10.91^{B} ± 0.35	11.94^{A} ± 0.34	11.43 ± 0.25

Means with the different superscript in each column with running alphabets and row with capital alphabets differ significantly ($P<0.05$). T_F = Thawing at refrigerated temperature, T_R = Thawing at room temperature.

TABLE 2. INFLUENCE OF FREEZING AND THAWING OF MUSCLE TISSUE (PIG) ON THE RELEASE OF ACP AND ALP IN THE MUSCLE PRESS JUICE (MEAN ±SE)

Days	ACP activity			ALP activity		
	T_F	T_R	Overall	T_F	T_R	Overall
0	1.46 ± 0.11	1.46 ± 0.11	1.46^{c} ± 0.07	1.03 ± 0.07	1.03 ± 0.07	1.03^{c} ± 0.04
7	2.05 ± 0.11	1.97 ± 0.09	2.01^{c} ± 0.07	1.01 ± 0.13	0.83 ± 0.17	0.92^{c} ± 0.10
15	1.54 ± 0.15	1.71 ± 0.11	1.62^{cd} ± 0.09	2.53 ± 0.28	1.95 ± 0.10	2.24^{b} ± 0.19
30	2.47 ± 0.11	2.62 ± 0.10	2.55^{b} ± 0.08	1.19 ± 0.10	2.43 ± 0.11	1.81^{ac} ± 0.28
60	2.92 ± 0.10	2.54 ± 0.08	2.73^{b} ± 0.10	1.81 ± 0.14	2.22 ± 0.13	2.01^{bc} ± 0.13
90	3.52 ± 0.10	3.50 ± 0.03	3.51^{a} ± 0.05	3.44 ± 0.18	3.80 ± 0.49	3.62^{a} ± 0.24
Overall	2.33 ± 0.18	2.30 ± 0.17	2.32 ± 0.12	1.83 ± 0.22	2.05 ± 0.25	1.94 ± 0.16

Means with the different superscript in each column differ significantly ($P<0.05$)

TABLE 3. INFLUENCE OF FREEZING AND THAWING OF MUSCLE TISSUE (PIG) ON THE RELEASE OF GOT AND GPT IN THE MUSCLE PRESS JUICE (MEAN ± SE)

Days	GOT activity			GPT activity		
	T_F	T_R	Overall	T_F	T_R	Overall
0	4.63 ± 0.35	4.63 ± 0.35	4.63 ± 0.22	1.66 ± 0.12	1.66 ± 0.12	1.66^{bcd} ± 0.08
7	4.67 ± 0.48	5.26 ± 0.75	4.97 ± 0.42	1.63 ± 0.11	1.57 ± 0.13	1.60^{be} ± 0.08
15	7.28 ± 1.39	4.60 ± 0.29	5.94 ± 0.87	2.14 ± 0.17	1.86 ± 0.12	2.00^{a} ± 0.11
30	7.72 ± 0.39	5.82 ± 1.48	6.77 ± 0.81	2.18 ± 0.18	1.71 ± 0.13	1.95^{ac} ± 0.15
60	4.51 ± 0.22	6.62 ± 0.87	5.57 ± 0.62	1.80 ± 0.16	1.84 ± 0.13	1.82^{ace} ± 0.09
90	8.04 ± 0.44	3.16 ± 0.90	5.60 ± 1.18	2.02 ± 0.13	1.82 ± 0.13	1.92^{ad} ± 0.09
Overall	6.14^{A} ± 0.44	5.02^{B} ± 0.39	5.58 ± 0.31	1.91 ± 0.07	1.74 ± 0.05	1.82 ± 0.04

Means with the different superscript in each column with running alphabets and row with capital alphabets differ significantly (P<0.05)

TABLE 4. INFLUENCE OF FREEZING AND THAWING OF MUSCLE TISSUE (PIG) ON THE RELEASE OF LPDH, LDH AND SDH IN THE MUSCLE PRESS JUICE (MEAN ± SE)

Days	LPDH activity		LDH activity				SDH activity		
	T_F	T_R	T_F	T_R	Overall	Overall	T_F	T_R	Overall
0	7.56 ± 1.25	7.56 ± 1.25	7.56^{bc} ± 0.79	4.68 ± 0.22	4.68 ± 0.22	4.68^{b} ± 0.14	2.80 ± 0.19	2.80 ± 0.19	2.80^{b} ± 0.12
7	47.90 ± 16.11	11.49 ± 1.50	29.69^{a} ± 10.89	24.44 ± 9.09	14.32 ± 2.71	19.38^{b} ± 4.81	3.17 ± 0.21	5.99 ± 1.61	4.58^{a} ± 0.96
15	36.22 ± 7.43	21.73 ± 2.11	28.97^{a} ± 4.74	8.71 ± 1.56	7.20 ± 1.49	7.96^{b} ± 1.03	5.69 ± 1.12	3.86 ± 0.29	4.77^{a} ± 0.66
30	47.17 ± 6.42	14.52 ± 1.92	30.85^{a} ± 7.89	38.97 ±19.76	27.92 ± 5.57	33.44^{a} ± 9.51	6.24 ± 0.91	5.04 ± 0.63	5.64^{a} ± 0.56
60	18.97 ± 4.75	14.14 ± 1.75	16.56^{bc} ± 2.51	17.18 ± 2.86	15.58 ± 2.91	16.38^{b} ± 1.86	5.37 ± 0.83	5.12 ± 0.47	5.24^{a} ± 0.43
90	12.49 ± 4.52	9.92 ± 0.23	11.20^{c} ± 2.11	–	–	–	6.67 ± 0.82	5.62 ± 1.05	6.15^{a} ± 0.64
Overall	28.39^{A} ± 4.82	13.23^{B} ± 1.22	20.81 ± 2.76	18.79 ± 4.94	13.94 ± 2.47	16.37 ± 2.75	4.99 ± 0.44	4.74 ± 0.39	4.86 ± 0.29

Means with the different superscript in each column with running alphabets and row with capital alphabets differ significantly (P<0.05)

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Physico-chemical Changes During Maturity of Mango *(Mangifera indica L.)* Variety "Neelum"

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Studies were carried out on the physico-chemical composition of the developing mango *(Mangifera indica L.)* fruits of variety "Neelum" during fruit maturation. The results showed that fruit growth in terms of weight, height and diameter was rapid initially with an increase in stone and pulp percentage upto 70 days after fruit set. The specific gravity and texture of the fruits (penetration. kg force) also increased with fruit development and reached a peak of 1.14 and 12.28 kg force respectively at 70 days after fruit set. Acidity and ascorbic acid content in developing fruits increased upto 90 and 70 days after fruit set, respectively and then decreased to 1.5% and 70.5 mg/100 g, respectively at 110 days after fruit set. The levels of total soluble solids (TSS), total sugars, total carotenoids increased gradually with the maturity upto 120 days after fruit set. Results did not show significant changes in physico-chemical characteristics between 110 and 120 days after fruit set. Hence, the optimum stage of maturity for harvest of mango variety "Neelum" is 110 days after fruit set. TSS in the pulp and the penetration force of the fruit can also be used as indices for fixing the optimum stage of maturity for harvest of "Neelum" mangoes.

Keywords : Mango, Neelum, Fruit set, Optimum maturity, Harvest, Physico-chemical composition.

Although considerable amount of work has been done on growth and development of commercially important varieties of mango *(Mangifera indica L.)* fruits in India, literature on physico-chemical changes associated with fruit growth and maturation in late maturing varieties of mango such as "Neelum" is rather scanty. Singh et al (1976) studied a few aspects of physiological and biochemical changes associated with the fruit maturity in "Neelum" variety. Detailed information regarding physico-chemical changes associated with fruit growth and development during maturation would be useful to determine the optimum stage of maturity for harvest. Therefore, the present investigation was undertaken to study various physico-chemical changes during fruit maturation to determine the optimum stage of fruit maturity for harvest of "Neelum" mangoes.

Twenty five mango trees of "Neelum" variety distributed in the randomized block design with three replications were selected from a healthy mango orchard of 20 years old, at Maniganahalli village, Kolar district of Karnataka State. Ten developing fruits from each tree were tagged ten days after fruit set. Thirty tagged fruits from three replications were harvested at 30, 70, 90, 100, 110 and 120 days after fruit set and were used for physico-chemical studies. Mean values of 30 fruits for each of the observations have been presented.

Destalking and desapping were carried out and fresh fruit weight was recorded. Fruit height and fruit diameter were measured with the help of Vernier calipers. Specific gravity of individual fruits at each stage was determined based on the fruit weight and the fruit volume (measured by water displacement).

The textural property (penetration) analysis of the developing fruits was measured and expressed in kg. force by using a vertical probe with a diameter of 5 mm and with a depth of 10 mm on Instron Model 4301 (Rushing and Huber, 1983).

The colour of the fruits at different stages of development was measured using UV-visible colour recording spectrophotometer (Shimadzu UV 2100, Japan) at wave lengths ranging from 360 nm to 800 nm, and expressed as L, a and b Hunter color values (Hunter 1975).

At each stage of fruit maturation, pulp, peel and stone components were separated from individually weighed six fruits. Per cent increase of pulp, peel and stone was estimated based on individual component weight and whole fruit weight (Table 1).

Chemical analysis : The pulp of five fruits in triplicate at each stage was macerated in a Waring blender and the three homogenates were used for chemical analysis. Total soluble solids (°Brix) of pulp were determined with the help of hand refractometer and pH was recorded by using a digital pH meter. Total sugars, acidity, ascorbic acid and total carotenoids in pulp were determined as per the methods suggested by Ranganna (1986).

Physical characteristics : The height, diameter and weight of fruits of "Neelum" mangoes (Table 1) increased upto 120 days after fruit set. During early stages of fruit development, fruit growth in terms of height, diameter and weight increased more rapidly from 30 to 70 days after fruit set. Lakshminarayana et al (1970) and Tandon and Kalra (1986) reported similar observations on fruit growth during fruit maturation in "Alphonso" and "Mallika" varieties of mango, respectively.

It is evident from the data in Table 1 that specific gravity increased in developing fruits from 1.04 to 1.14 between 30 and 70 days after fruit set. This was mainly due to proportionate increase in fruit weight and fruit volume during early stages of fruit growth. Specific gravity decreased to 1.06 and 1.07 at 110 and 120 days after fruit set respectively. Specific gravity of the fruit is considered to be one of the important maturity indices of mango (Mann and Singh 1973). It was observed that specific gravity decreased as fruit growth advanced towards maturity However, Singh et al (1976) reported that the specific gravity of "Neelum" fruits was continuously increased with maturity. The present study on "Neelum" mangoes did not show a definite trend in specific gravity during maturation and hence, cannot

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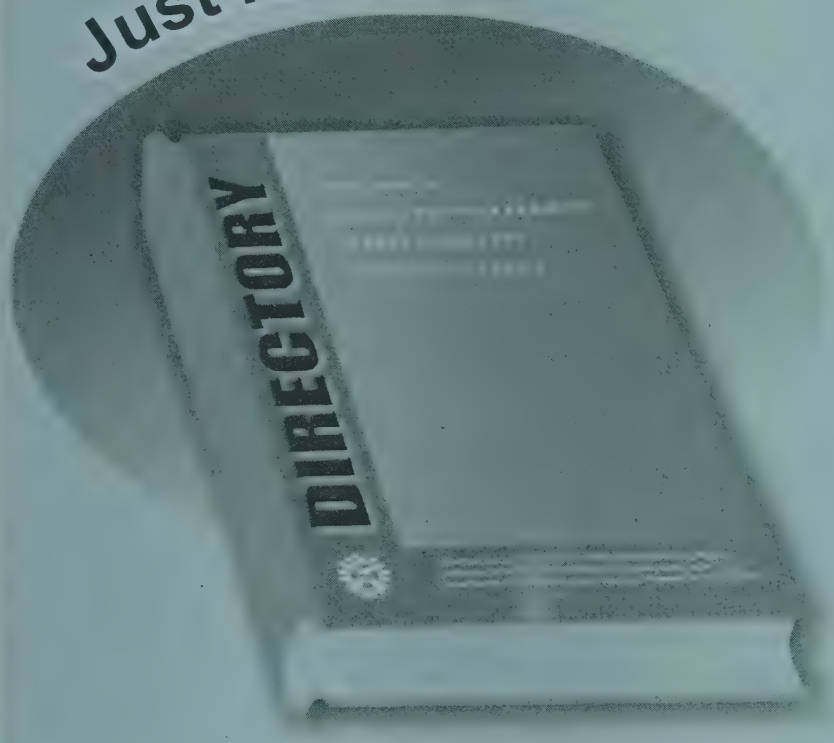

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TABLE 1. PHYSICO-CHEMICAL CHANGES DURING FRUIT MATURATION OF MANGO VARIETY "NEELUM"

Parameters		Days after fruit set					
		30	70	90	100	110	120
Fruit wt, g		17.0 ± 0.70	151.8 ± 26.77	174.0 ± 7.78	202.0 ± 4.65	225.0 ± 27.03	227.4 ± 9.25
Height, cm		4.0 ± 0.31	8.0 ± 0.87	8.2 ± 0.92	8.3 ± 0.49	8.5 ± 0.37	8.6 ± 0.37
Diameter, cm		3.1 ± 0.17	6.3 ± 0.40	7.0 ± 1.19	7.2 ± 0.79	7.4 ± 0.37	7.5 ± 0.23
Sp. gravity (g/cc)		1.04 ± 0.02	1.14 ± 0.10	1.11 ± 0.19	1.13 ± 0.32	1.06 ± 0.18	1.07 ± 0.14
Stone, %		3.89 ± 0.14	13.80 ± 0.79	14.00 ± 2.63	14.22 ± 1.48	14.98 ± 1.31	15.00 ± 1.08
Pulp, %		69.49 ± 1.33	66.90 ± 2.02	70.14 ± 2.06	71.02 ± 3.50	73.42 ± 2.42	73.80 ± 2.69
Peel, %		26.62 ± 1.15	19.30 ± 1.07	15.86 ± 1.13	14.76 ± 1.41	11.60 ± 1.28	11.20 ± 0.96
Hunter values,	L	38.95 ± 1.57	39.57 ± 2.68	36.30 ± 2.22	33.80 ± 1.84	31.13 ± 2.63	26.41 ± 2.11
in peel	a	−4.38 ± 0.50	−4.01 ± 0.28	−3.98 ± 0.49	−3.00 ± 0.29	−2.79 ± 0.51	−2.33 ± 0.20
	b	17.72 ± 1.18	13.44 ± 1.02	12.27 ± 1.18	11.38 ± 1.47	9.58 ± 1.42	8.17 ± 0.27
Hunter values,	L	78.98 ± 1.05	84.33 ± 3.78	82.81 ± 2.61	80.61 ± 2.88	83.09 ± 1.68	79.21 ± 3.15
in pulp	a	−5.27 ± 0.57	−3.48 ± 0.64	3.46 ± 0.48	3.66 ± 0.45	4.01 ± 0.23	5.62 ± 0.51
	b	24.37 ± 1.27	19.84 ± 1.64	29.64 ± 1.93	26.09 ± 0.75	33.93 ± 1.65	35.49 ± 1.88
Textural properties							
Penetration, kg. force		8.33 ± 0.69	12.28 ± 1.23	9.87 ± 0.61	9.36 ± 0.32	8.66 ± 0.48	8.53 ± 0.76
TSS, °Brix		6.4 ± 0.29	6.0 ± 0.43	7.0 ± 0.55	7.0 ± 0.71	8.0 ± 0.50	8.0 ± 0.25
pH		3.9 ± 0.43	3.0 ± 0.34	3.0 ± 0.34	3.0 ± 0.52	3.1 ± 0.34	3.1 ± 0.26
Acidity, %		1.0 ± 0.34	1.8 ± 0.31	1.9 ± 0.34	1.8 ± 0.29	1.5 ± 0.26	1.5 ± 0.26
Total sugars, %		2.1 ± 0.39	2.5 ± 0.25	2.9 ± 0.37	3.0 ± 0.25	3.8 ± 0.46	3.7 ± 0.42
Ascorbic acid, mg/100g		42.0 ± 3.41	74.0 ± 2.94	72.0 ± 4.83	72.0 ± 3.82	70.5 ± 3.20	71.0 ± 3.44
Total carotenoids, µg/100g		150.2 ± 3.15	170.1 ± 3.27	198.3 ± 7.73	216.0 ± 3.55	263.0 ± 4.86	265.0 ± 4.32

Values are the Mean ± SEM of three individual estimations

be used as maturity index for harvest.

Distribution of components (%) of whole fruit : Results on the distribution of components of fruit such as pulp, peel and stone showed that the pulp constituted the major portion of the fruit at each stage. During early stages of fruit development (between 30 and 70 days after fruit set), the extent of increase in stone growth was more predominant than the pulp and peel. As the fruit growth advanced towards maturity, the pulp percentage increased to 73.42 at 110 days after fruit set, with cessation of stone growth. Peel percentage showed a decreasing trend with the progress of maturity upto 120 days after fruit set. Tandon and Kalra (1986) have also made similar observation in the per cent distribution of peel, pulp and stone during fruit development and maturation in "Langra" and "Mallika" varieties of mango.

Changes in colour reflectance and textural properties of mango fruits during fruit development and at maturity : Changes in the colour reflectance of both peel and pulp portion of "Neelum" mangoes was measured in terms of Hunter colour values (L, a and b). The lightness (L) in the pulp of fruit was more than the peel at all the stages of fruit growth, which decreased gradually with the progress of maturity, whereas lightness (L) of the pulp did not. Yellowness (b) in the peel decreased from 30 days till maturity and was lowest at 120 days after fruit set (8.17). At each stage, the intensity of yellowness in the pulp was more than that of peel indicating increased levels of total carotenoids. Yellowness in the pulp increased as fruit growth advanced towards maturity and attained a peak of 35.49 at 120 days and this due to higher levels of carotenoid was pigments (265 µg/100 g) at 120 days. Although a slight increase in yellowness (b) of the pulp was observed at 120 days after fruit set as compared to 110 days, the difference was not significant (Table 1).

The data on penetration as an index of firmness of the fruit texture revealed that there was gradual increase in firmness of the fruits as fruit growth advanced from 30 days to 70 days after fruit set followed by gradual decrease with the progress of maturity. It indicated that developing fruits at 70 days after fruit set offered higher resistance to the force applied with compression and were comparatively more firm than in fruits at 110 and 120 days after fruit set. The results showed that firmness measurement of the fruit could be used as index for fixing optimum stage of maturity for harvest.

Chemical characteristics : The total soluble solids (TSS) content of the fruit pulp decreased upto 70 days after fruit set (6.0°Brix), followed by an increase at 110 days after fruit set (8.0°Brix). TSS content did not show any change at 120 days after fruit set. Singh et al (1976) and Tandon and Kalra (1986) also reported similar changes in TSS during fruit maturity. The results clearly indicated that TSS measurement could be used as a simple and reliable index to fix the optimum stage of maturity for harvest. pH value decreased and acidity increased upto 90 days after fruit set. Later, pH slightly increased and acidity slightly decreased at 110 days after fruit set. The present results are in agreement with those reported by Singh et al (1976). The total sugars (TS) and total carotenoids (TC) levels in the fruit pulp gradually increased upto 110 days after fruit set and reached the maximum of 3.8% TS and 263 µg/100 g TC on fresh weight basis. Singh et al (1976) also observed similar pattern in TS content of developing "Neelum" fruits during

maturation. The ascorbic acid content of fruit pulp increased from 42 mg/100 g at 30 days after fruit set to a maximum of 74 mg/100 g on fresh weight basis at 70 days, there after it decreased to 70.5 mg/100 g at 110 days. Mukerjee and Tewari (1979) also reported similar observation in "Langra" variety of mango.

Studies carried out on changes in physico-chemical characteristics in the "Neelum" mango fruits at different stages of growth and maturity indicated that the fruits reached optimum stage of maturity at 110 days after fruit set. Among the various physico-chemical characteristics studied, firmness measurement of the fruit and TSS could also be used as indices for fixing the optimum stage of maturity for harvest.

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PROCESS BIOTECHNOLOGY FUNDAMENTALS : Written by S.N. Mukhopadhyay, Published by Viva Books Pvt. Ltd., 4262/3, Ansari Road, Daryaganj, New Delhi - 110 002, 2001, pp 409, Price : not mentioned.

This book is somewhat different from other bioprocess engineering books available, covering the most important areas under the subject including modern biotechnological processes. The first chapter introduces the subject of process biotechnology as an interdisciplinary subject of biosciences, engineering and biotechnology in relation to the modern global developments. In the second chapter, it covers cell biological events, structural engineering of DNA, biomolecular design engineering tools and the important application areas. Chapter 3 is concerned with medium design and metabolic engineering. The fourth chapter covers the strategies in new bioprocessing involving cell synchronization, multi-interacting bioprocessing and cycling and profiling of important variables like temperature and pH to increase the bioreactor performance.

Chapters 5 and 6 deal with bioreactors, scale-up and monitoring of bioprocesses through biosensors. They cover scale up aspects involving microbial, mammalian and plant cell processes as well as genetically engineered cell cultures. Modern methods of estimation using mass spectrometry, light scattering, PCR, chromatography and flow injection instrumental analysis are dealt with in Chapter 7. Conventional and modern methods of product recovery in bioprocesses are discussed in Chapter 8. Biotechnological treatment of water effluents, potable water and genetically engineered cell processing effluents are presented in Chapter 9. Chapter 10 is dedicated to processing for the production of cellulases and bioconversion of lignocellulosic wastes. A separate and detailed Chapter 11 deals with stress proteins production, molecular biology of cells under stress, kinetics, upstream and downstream processing of such products, which the prominent contributions of this book. While Chapter 12 gives an example of penicillin plant design calculations in an exhaustive way, dealing with all aspects of media and reactor design, downstream processing operations, design of all auxiliary equipment, solvent recovery, material and energy balances etc. concerned with penicillin production. Chapter 13 outlines practice tutorials.

The book has some drawbacks, most notable of which is the lack of meaningful expressions in the English language and many grammatical errors. The latter are too numerous to detail here and the book needs a thorough relook on this aspect. Many sub-heads do not convey the message meaningfully. Another drawback is that the book, in part seems to specifically be addressing Indian situation, thus becoming not so attractive for global readers. This shortcoming is glaringly evident in the introductory Chapter 1. Although Chapter 6 deals with mammalian and plant cells as well as genetically engineered cells, a more detailed treatment with respect to bioprocessing of these systems could have made the book more useful and attractive to biotechnologists and biochemical engineers. The chapter on cellulose processing is useful to selective readers only but brings out the research experience of the author in his own laboratory.

Overall, the book is a useful addition to practising biotechnologists and libraries which include collection of books in this area. Chapter 11 on bioprocessing of stress proteins as well as the exhaustive chapter on the design calculations on the complete penicillin production plant add strength to the book.

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Erratum :

The authors of the article 'Effect of Peeling Methods on Breadnut *(Artocarpus altilis)* Seeds and Acceptability of Canned Breadnut Seeds in Brine' published in Volume 38, No. 4, p. 402-404, 2001 should read as R. Matthews, N. Badrie, G. Baccus-Taylor and E. Commissiong.

The mix-up is regretted - Editors

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